Instruments

THE MAGAZINE OF Measurement and Control

Vol. 12
FEB.
1939
No. 2

TAG

Sensitive *to* TEMPERATURE
NOT Sensitive *to* VIBRATION

TAG CELECTRAY means high sensitivity, photoelectric detection, and split-second response—practically instantaneous control. Does this mean sensitivity to vibration? Not in the TAG CELECTRAY Indicating Controller Model No. V. **This Controller is sensitive to temperature change but NOT to vibration.**

Hammer the panel with the instrument mounted rigidly . . . No response —unless the temperature changes at the same time. Mount the instrument rigidly on a panel with the contactor or next to a drop hammer if you wish . . . The damped response of the photoelectric circuit of the instrument selects the gradual change of temperature for control but will not respond to the severest vibration.

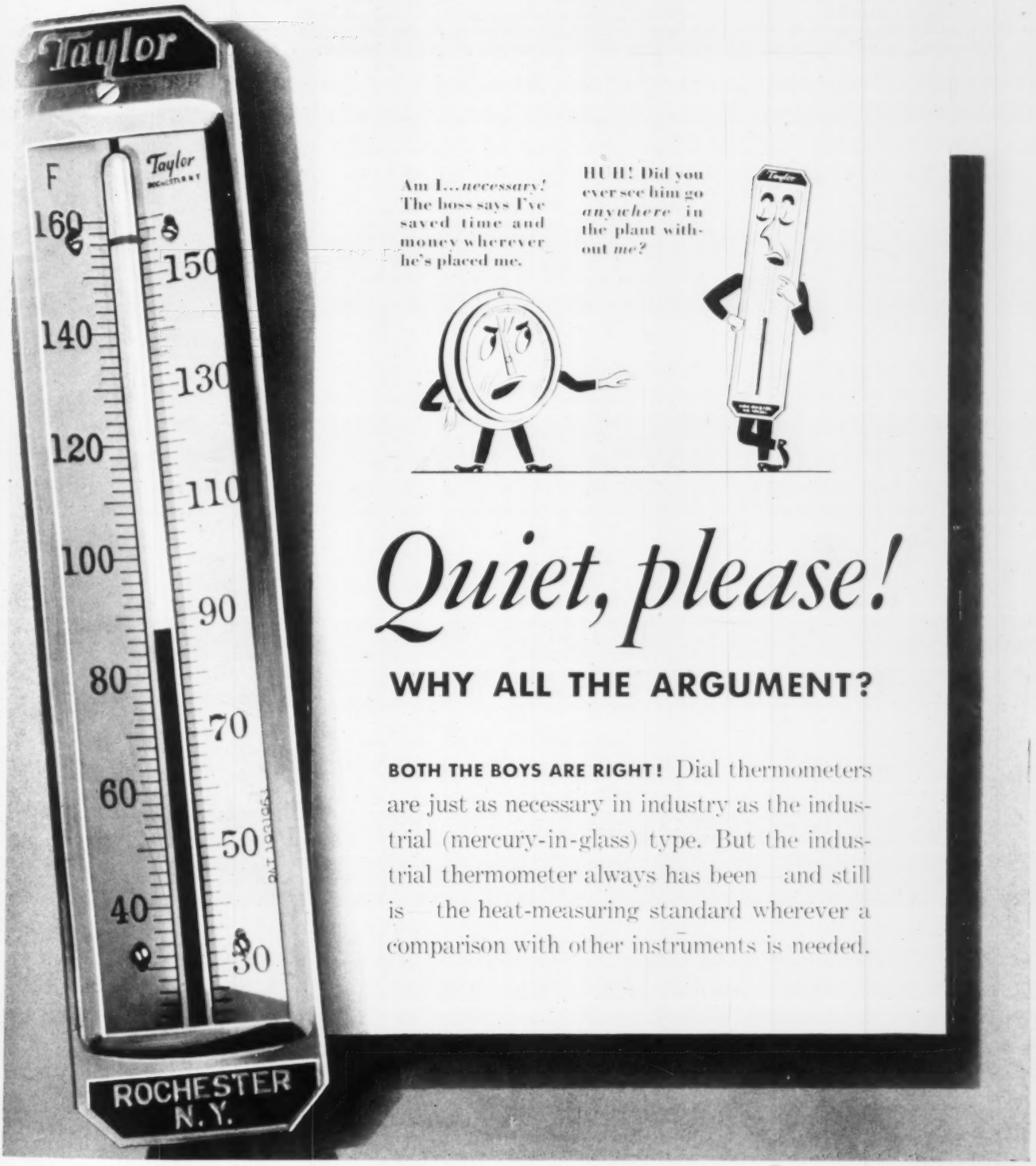
CELECTRAY substantially reduces both extent and duration of fluctuations —*guaranteed* "to control more closely than any instrument has controlled before."

We invite your interest in this extraordinarily sensitive Indicating Controller which does not require vibration-proof mountings . . . Ask for the facts.

C. J. TAGLIABUE MFG. CO.

Park & Nostrand Ave's., Brooklyn, N. Y.

TAG TAGLIABUE BROOKLYN N.Y.



Quiet, please!

WHY ALL THE ARGUMENT?

BOTH THE BOYS ARE RIGHT! Dial thermometers are just as necessary in industry as the industrial (mercury-in-glass) type. But the industrial thermometer always has been — and still is — the heat-measuring standard wherever a comparison with other instruments is needed.

NO MATTER how varied the need for dial thermometers to measure heat, it's safe to say that nothing can take the place of the industrial (mercury-in-glass) thermometer in your plant—or any other.

That's why Taylor has always made the finest, most accurate industrial thermometer science can produce—and why today Taylor offers you the BINOC Thermometer which adds "easier-to-read" to the established accuracy.

In BINOC tubing, Taylor scientists record a major advance in thermometer tube construction...a development with features long-desired for assuring easier and more accurate readings at normal and greater-than-normal distances.

Among the features of BINOC tubing are: wider mercury column, wider angle of vision, absence of bore reflection—and three times the amount of light concentrated on more extended background.

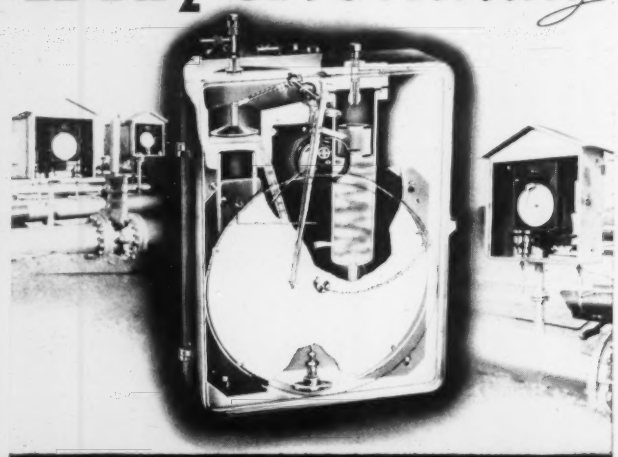
The Taylor BINOC Thermometer shown here may not have the right range for your plant. But there is one which does have. Send for the Taylor Representative, or get complete data from Taylor Instrument Companies, Rochester, N.Y. Plant also in Toronto, Can. Manufacturers in Great Britain —Short & Mason, Ltd., London, Eng.

Taylor

Indicating Recording Controlling

TEMPERATURE, PRESSURE, FLOW *and* **LEVEL INSTRUMENTS**

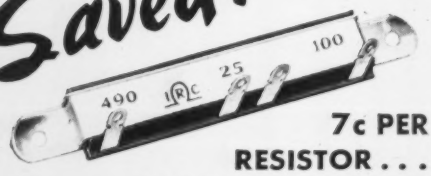
X-ray of *Accuracy*



THE WESTCOTT Orifice Meter... the instrument that is meeting a demand of astonishing size and growth throughout the world. Large volume, efficient manufacturing, ingenious design and simplicity ... these alone make the low cost possible.

AMERICAN METER COMPANY
METRIC METAL WORKS *ERIE, PENNSYLVANIA*

Saved!



7c PER RESISTOR . . . AND 2½" OF SPACE!

THIS adaptation of a standard IRC Resistor made for a well-known manufacturer replaced 3 separate resistors previously used, saved 7c on cost, 2½" of space, and greatly simplified production assembly. Many equally important resistor savings have been made for others. Whatever your resistor problem — or even if you have no problem — write to IRC. Our engineers will be glad to submit samples, make money-saving suggestions based on eighteen years' experience in producing more resistance types, in more shapes, for more applications than any other manufacturer in the world.

IRC
INTERNATIONAL RESISTANCE COMPANY
417 N. Broad St., Phila., Pa.

Instruments

THE MAGAZINE OF MEASUREMENT and CONTROL

VOL. 12 No. 2

FEBRUARY, 1939

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Instruments

THE MAGAZINE OF Measurement and Control

J. F. BEHAR, Editor

That Old Question of Repairs

EVERY now and then we come across a new proof of the saying that repair costs are only a fraction of repair expenses. Here is the latest: In a St. Louis industrial plant a recorder-controller was accidentally damaged. Examination showed that the repair was beyond the facilities of the plant's own instrument department. Accordingly, it was turned over to the authorized St. Louis dealer of the—let's call it "Baygolrup Instrument Co." This man runs a mill supply house—not a "Baygolrup" factory branch. In his zeal to save his customer's time and money he sent the recorder-controller to a nearby instrument repair firm instead of to the "Baygolrup" factory in New England.

Result: an unsatisfactory repair job. Consequences: lost time, imperfect processing, a costly proportion of seconds and rejects—a total expense hundreds of times greater than the saving aimed at by the well-intentioned mill supply house.

In the end, the recorder-controller had to be sent to the "Baygolrup" factory. It should have been sent there in the first place. *All* measuring instruments and control devices requiring repairs beyond your facilities should be sent to the original manufacturer. Only then can you be sure that they will be returned to you in the shortest time consistent with quality. Even our readers on one coast will find it safer to have repairs done by original manufacturers on the other coast if such manufacturers do not have branch factories. But, as a matter of fact, most of the companies which manufacture extensive lines of industrial instruments—including recorder-controllers, etc.—have well-equipped branch factories throughout the country. Your editor visited four of these in San Francisco and Los Angeles—not only visited them but inspected them critically, and if these four are typical of the fifty or so throughout this country and Canada, then there's no excuse for going to cut-rate repair shops. We say cut-rate repair shops because there are also repair shops duly accredited by several instrument manufacturers who do not maintain branch factories. The situation is somewhat complex, however, as shown by a recent instance: In a city near New York, the representative of one instrument manufacturer was reported to be soliciting repair business from users of *all makes* of industrial instruments, claiming competence to repair all. This claim is vigorously denied by the engineers of some other instrument companies—who inform us also that their objection is not based on a competitor "musclng" into their business—because *their* repair departments are not run for profit.

On the whole, we see no reason for modifying the advice we gave in a 1932 editorial entitled "True and False Repair Economy":

> Do not send good dollars after bad pennies by repairing obsolete instruments, instead of replacing them by improved models at a cost which in some cases is lower than that of repairs.
>
> Where an instrument or control system can conveniently be removed, it should preferably be sent to the original manufacturer who can of course replace the unserviceable part with an exact duplicate.
>
> Bootleg parts "look" all right" but in some cases they impair the accuracy or value of the instrument or system.

There certainly are no better renewal parts for your instruments than those made by the original manufacturer or his authorized service laboratories. Moreover, the repair work will be done (or in any case supervised) by factory-trained engineers. Yes, *engineers!* To quote one company:

> These men are not general mechanics, nor "handy-men," repairing instruments and radios with equal ease and unconcern. They are men of recognized standing in the engineering world, graduates of scientific institutions; most of them hold the degree of M.E.

Come to Pittsburgh March 2

Plan to attend the conference on Instrumentation in the Process Industries at Carnegie Tech, Pittsburgh. Be in room 104, Industries Hall, at 8:45 a. m. on Thursday, March 2 and arrange to stay till Friday afternoon. Here are some high spots:

"General Principles of Instrumentation" by Professors C. S. Draper and G. V. Schliestett of M.I.T.

"Process Controls in the Salt Industry" by N. Berry, General Foods Corp., and H. W. Diamond, Diamond Crystal Salt Co.

"Some Problems in Instrumentation in Petroleum Refining" by W. K. McCoy, Gulf Oil Company.

"Recent Developments and Operation of Instruments for Controlling Cracking Equipment in Response to Yield Per Pass and *in Situ* Density" by R. L. Rude, British-American Oil Co. and C. Barnes, University of Toronto.

"Instrumentation on Solvent Dewaxing Process" by G. C. Thrift, The Texas Co.

"Instrumentation in the By-products Plant" by E. L. Nuttall, Carnegie-Illinois Steel Corp.

"Instruments for Control of TVA Electric Furnace Phosphoric Acid Plant" by J. N. Jinkins and R. H. Newton.

"A Course in Industrial Instrumentation as Given at the Charleston Evening Trade School" by C. B. Cochran, Westvaco Chlorine Products Corp.

Other speakers: E. J. Partridge of Hall Labs., M. T. Carpenter and H. F. Moore of S.O., G. Egloff of Univ. Oil Products, L. W. Bass of Mellon Institute, Everett S. Lee of G-E, etc.

THE MONTH'S NEW INSTRUMENTS

In this department we strive to report each month ALL the new devices for measurement, inspection, testing, metering and automatic control—in the form of concise technical descriptions.

When writing to manufacturers directly, please mention this department as your source of information.

Or write to Information Section, Instruments Publishing Company.

Cable Fault Locator

For locating power cable faults in minimal time, Morse-Newhall Test Assembly is a new modification of Murray Loop circuit which operates at voltages up to 100 kv. and obviates need for breaking down fault resistances. Slide wire 185" long affording 0.01% intrinsic accuracy permits locating most faults after a single measurement. New assembly is adapted also for

Wheatstone bridge measurements and for approximations of resistances by voltmeter method, thus permitting analyzing faults on same instrument used to locate them.—*Leeds & Northrup Co., 4955 Stenton Ave., Philadelphia, Pa.*

Magnetic Focusing Yoke

New "Type T-701" magnetic focusing yoke is for use with short-neck television tubes, etc., designed for magnetic focusing. Its d-c. resistance is 1000 ohms; current for 500 ampere-turns is 70 ma. and maximum current is 85 ma. Width 1¾", inside diam. 1⅛"; outside diam. 3¾"; flange diam. 4½"; four mounting holes. Magnetic circuit is designed to concentrate a flux pattern of proper shape in neck of tube to focus electron stream. Mechanical design with air gap at one end prevents interference with deflection yoke.—*Kenyon Transformer Co., Inc., 840 Barry St., New York City.*

Moisture Tester

"Moisture Teller" (see *Instruments*, June 1935, page 164) is now provided with an adjustable thermostat which holds at any temperature between 135 and 250° F.; and with a thermometer.

Harry W. Dietert Co., 9330 Roselawn Ave., Detroit, Mich.

Glareless Glass

Welcome news to instrument users comes in two nearly-simultaneous announcements of methods for making glass glareless. Both methods consist in applying thin (130- to 140-mμ) films to surface of glass.

(1) Drs. C. H. Cartwright and A. F. Turner of M.I.T. evaporate fluorine compounds on surface of glass until desired film thickness is built up, reducing reflectivity (which is approx. 8% in the case of ordinary instrument glass under ordinary conditions) to approx. 0.4%.

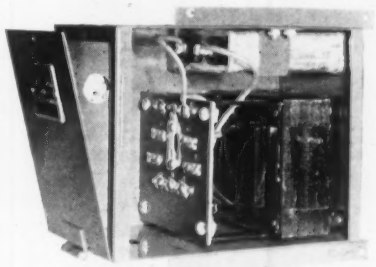
(2) Dr. Katharine Blodgett of G-E transfers monomolecular films of barium stearate, cadmium arachidate, etc., floating on water, to glass by a dipping technique, the operation being repeated approx. 42 times until desired thickness is built up, reducing reflectivity to approx. 0.8%. Illustration shows a G-E instrument in which half the

glass has been treated. Dr. Blodgett's method—an offshoot of her years of research in the production and utilization of monomolecular films originated in 1934 by G-E's Langmuir and Whitney—is said to permit controlling the chemical composition of the film so that its refractive index will be suited to that of the glass.

As yet, neither the M.I.T. method nor the G-E method is commercially available. It must also be borne in mind that only under monochromatic illumination can either make glass entirely "invisible." It is impossible to make a quarter-wave-length film eliminate all reflection of all wave-lengths in the visible spectrum because the visible spectrum extends over one octave—red-light waves being twice as long as violet-light waves. Fortunately, the normal eye is many times more sensitive to yellow-green than to red or violet (eighty times more sensitive to $\lambda = 550$ mμ than to $\lambda = 425$ or to $\lambda = 690$) and, moreover, the artificial illumination from most of the modern lamps has its spectral-distribution center of gravity close to that of the I.C.I. Normal Visibility Curve. Each set of workers has, therefore, selected a wave-length close to this center of gravity (the M.I.T., green; the G-E, yellow; according to latest reports). Moreover, a film thickness suited to a given visible wave-length is not altogether unsuitable for other visible wave-lengths—even a film "calibrated" for a wave-length in the ultra-violet produces a noticeable reduction of glare under full white illumination.—(*Instruments.*)

A-c. Motor Speed Controller

New multi-step speed controller for [illegible] motors makes it possible to vary motor speed by changing input voltage, thereby permitting motor to be operated by a thermostat or automatic switch because motor will always re-start regardless of control



setting. Principal components are an auto-transformer with voltage adjustment taps and an oil-filled condenser; "no moving parts and nothing to wear out." New speed controllers are custom built, sold only in quantities. Methods of mounting and of voltage control are selected to suit customer's needs.—*Raytheon Mfg. Co., 13 Willow St., Waltham, Mass.*

Aviation Radio Receiver

New "blind flying" instrument in effect creates a trail of fixed radio landmarks enabling airplane pilots to check their progress along the airways and to spot airport approaches. Known as the "27A Aviation Radio Receiver," it operates in conjunction with Civil Aeronautics Authority's transmitters which send out "marker" signals on 75 Mc. directly above each station in either a fan or a cone-shaped signal pattern. Entering this field, receiver delivers a characteristic tone enabling pilot to identify station; and flashes colored signal lamps, each corresponding with one type of marker transmitter. New receiver requires no operating attention while in flight, contains no relays or other moving parts, weighs 193 lbs. complete, is housed in 19" × 5" × 7" case, may be arranged for operation either from 12 volts d.c. or from a 110-volt, 800-cycle power supply.—*Western Electric Co., 195 Broadway, New York City.*

Time Switch

New "300 Series" is radically different in appearance and in operation from maker's "Time Control" line, is said to represent "a new type of switching operation . . . free of all complicated cams." It consists of a back-and-forth snap-action tripping lever actuated by trippers on dial. This can be manually operated without changing automatic switching sequence. Rated capacity is 3000 watts per pole. All electrical

operations are back of the fixed face plate. Through a clock train of five gears floating on two fixed arbors, self-starting 450 r.p.m. synchronous motor drives 24-hr. dial.—*Paragon Electric Company, 37 W. Van Buren St., Chicago, Ill.*

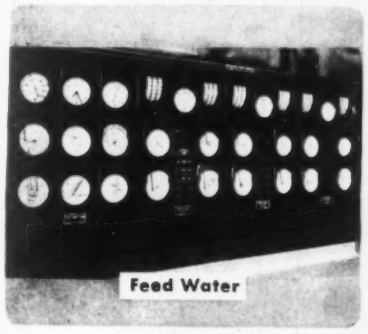
POSITIVE EXPLOSION PROTECTION

FLAME-OTROL

is a Wheelco "Radio Principle" instrument, designed to prevent explosion by instantly cutting off fuel supply if flame failure occurs. Furnishes complete automatic protection in lighting and operation.

Write for Bulletin No. 1105

Wheelco Instruments Co.
1933 So. Halsted St. Chicago, Ill.



The State University of Iowa uses these Cochrane Flow Meters to record water feed to their power plant boilers—one of the many installations and applications to which these meters are suited.

Cochrane Electric Flow Meters accurately measure and record the flow of—STEAM, for boiler output, distribution, turbine consumption, process and heating; WATER, for boiler feed input, pump discharge, condensate, well delivery, effluent and condenser circulation; AIR and GAS, for compressor discharge, distribution, furnace fuel, producer output and process; MISCELLANEOUS LIQUIDS and GASES, such as sewage, brine, oil, caustic soda, ammonia, oxygen, hydrogen, etc.

Cochrane Electric Flow Meters which are operated by the galvanometer null principle, are guaranteed for their accuracy and dependability.

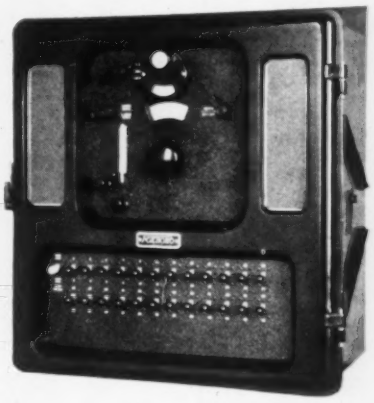
Write for Publication 2096

COCHRANE CORPORATION
5118 N. 17th St. Philadelphia, Pa.

COCHRANE
FLOW METERS

Key-Switch Cabinet Indicating Potentiometer

Maker's indicating potentiometer with multiple-point rotary selector switch (see *Instruments*, Jan. 1934, page 14) has been supplemented by a new key-switch cabinet model wherein as many as 82 switches may



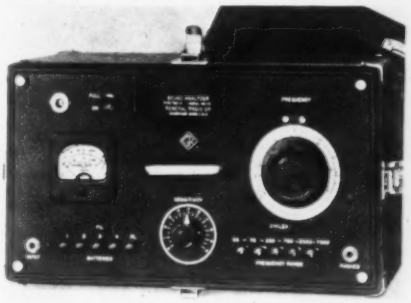
be obtained on the key-switch panel, and with switch-identification panels beside the potentiometer proper. Pressed-steel universal type case is suitable for surface or flush mounting. All connections are made from front of board. Case is provided with 10 knockout openings so that connections can be made at top, bottom or sides.—*The Fairbanks Co., 16 Neponset Ave., Foxboro, Mass.*

Covers for Instruments

Oiled silk covers for instruments have been developed in several materials, all providing waterproof and dustproof protection. As the new materials are transparent, readings may be made without removing this protective cover. Covers are made to fit any instrument.—*Blossom Mfg. Co., 79 Madison Ave., New York City.*

Portable Sound Analyzer

Designed particularly for analyzing noise and vibration generated by machines, etc., new Type 760-A Sound Analyzer is intended for use in conjunction with maker's Type 759-A Sound-Level Meter (*Instruments*, Oct. 1936, page 274) but can also be used



with any microphone for vibration pickup and amplifier combination which provides sufficient output voltage. It consists of a degenerative, selective amplifier and a logarithmic vacuum-tube voltmeter. Response frequency can be varied between 25 and 7500 cycles by means of a rotary dial and a set of push-button switches. Usable output indications can be obtained with inputs ranging from 1 millivolt to 10 volts. Scale is calibrated for reading directly component tones down to 1% of sound pressure of fundamental or loudest component. Approx. dimensions 15" x 10" x 12"; net weight 37 lbs.—*General Radio Co., 30 State St., Cambridge, Mass.*

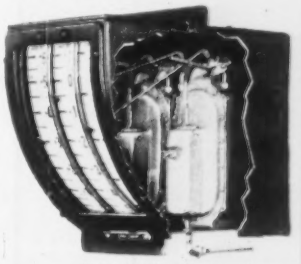
BAILEY METERS

METERS and CONTROL *for Boiler Room Service . . .*

Boiler Meters Indicate, record and integrate Steam Flow from the boiler, record Air Flow supplied for combustion and record Flue Gas Temperature. The use of this meter reduces fuel cost, lessens maintenance and outage, lowers standby costs, and adds capacity.

Bailey Boiler Meter

Multi-Pointer Gages for indicating drafts, pressures, differentials are available with any number of pointers from one to twelve. They are actuated by sturdy yet sensitive diaphragm units.



Multi-Pointer Gage

Flow Meters. For indicating, recording and integrating the flow of steam, feed water, compressed air and other fluids.

Coal Meter

Granular Material Meters For accurately measuring the flow of coal or other granular materials in gravity chutes from overhead bunkers. The total quantity of granular material is shown on a large illuminated counter which may be easily read at a distance of 50 feet.

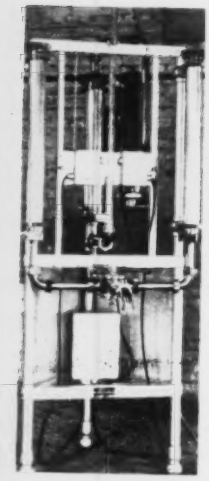
Control Systems. Make possible the everyday operation of equipment for steam generation and utilization at test efficiencies. They are applied to the control of combustion, feed water, superheat, desuperheat and other factors.

Complete Information on any of the above Bailey products will be gladly furnished upon request.

BAILEY METER COMPANY
1041 Ivanhoe Rd., Cleveland, Ohio

Automatic Volumeter-feeder; Photoelectric Relay

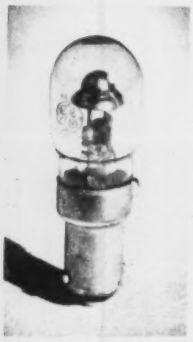
(1) Maguire Automatic Measurer is a positive liquid meter of the gravitational volumetric class, atmospheric-pressure multiple-tank type, with photoelectric means of measuring predetermined volumes and of actuating valves, so that entire assembly is an automatic intermittent volumeter-feeder. Illustration shows sanitary model designed for dairy industry and other applications requiring utmost anti-contamination construction as well as volumetric accuracy.—*The Walter Maguire Co., 11 W. 42nd St., New York City.*



(2) New "R2-10" Photoelectric Relay—the means whereby above-described equipment rapidly measures successive volumes and automatically dispenses them—is said to possess a combination of operating, wear-resisting, non-aging, non-chattering, anti-leakage and heat-resisting characteristics never achieved previously. Horizontal slit between gage-glass and phototube is $\frac{3}{4}$" wide and $\frac{1}{2}$" high. Design of light-source and amplifier is such that float in gage glass must almost completely cut off light to cause valves to be operated, so that liquid-level sensitivity is a small fraction of $\frac{1}{16}$", corresponding to a volumetric accuracy of the order of 0.01%. Among features of "R2-10" relay are a rectifier system producing d.c. for the amplifier to permit chatter-free relay action, also a two-tube amplifier (instead of customary method wherein the power tube is operated with 10 to 20 times maximum recommended grid resistance). In new unit, a buffer tube between phototube and power tube is operated with high grid resistance and the power tube is operated below maximum rating. Selection of tubes is not critical and ordinary commercial models offer a wide choice.—*Electrol Co., 54 W. 21st St., New York City.*

Glow Lamp for Instruments, &c.

New $\frac{1}{15}$-watt glow lamp equipped with a skirted miniature single-contact bayonet base is designed for such uses as testers, electrical instruments, pilot lights and indicators, also aviation, submarine and similar instruments where space factor is important. It is electrically identical to the double-contact-bayonet T $1\frac{1}{2}$ lamp, having no resistance built into base, therefore, external resistance must be of such value as to limit current to 2 ma. Electrode shape is hemispherical; only negative electrode glows on d.c. but candle power is same as that produced on a.c. Two types: neon-filled which may be used on either a.c. or d.c.; argon-filled usable on a.c. only. Overall length $1\frac{1}{2}$".—*General Electric Vapor Lamp Co., Hoboken, N. J.*



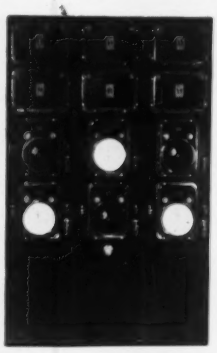
A 24-HOUR RECORD—giving accurate and dependable measurements so vital to efficient and economical operation.

Hays Combustion Meters employ the Orsat principle for measurement of CO_2. Water operated — no moving parts—extreme accuracy coupled with dependable performance.

There is a Hays Combustion Meter to fit every requirement—remote or integral mounting, indicating or recording or both. Write to 925 Eighth Avenue, Michigan City, Indiana, for free catalog.

The HAYS CORPORATION
COMBUSTION INSTRUMENTS AND CONTROL
MICHIGAN CITY, INDIANA, U.S.A.

FALSTROM



STEEL PANELS

FALSTROM Precisioned Steel Panels are specified by engineers for their Strength . . . Durability . . . Fine Appearance . . . for use in—

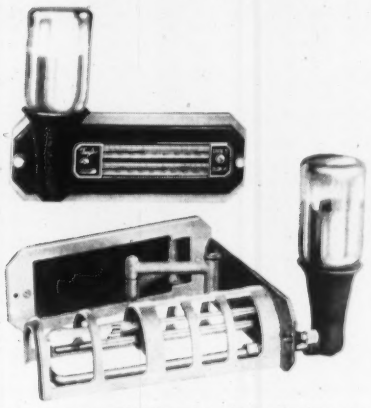
POWER PLANTS
OIL REFINERIES
PUBLIC UTILITIES
PROCESS INDUSTRIES
COMMUNICATIONS

Send blueprints. Write for bulletin P-2

FALSTROM COMPANY of PASSAIC N. J.

Hygrometer for Ducts, &

Overcoming inconvenience of almost complete dismantling of conventional-form wet & dry-bulb hygrometer when used on conditioning supply and return ducts, filters, etc., new Taylor Hygrometer affords complete accessibility for installation and routine servicing: by loosening two thumb screws, assembly swings out on a triple-hinged bracket. Moreover, wet & dry bulbs have been staggered, hence are exposed to proper circulation in either horizontal or vertical ducts. New type skeleton guard around bulbs is designed so as to have no heat capacity effect to alter temperature of air around bulbs or to hinder circulation. Scales are etched on flat glass thermometer tubes, mounted horizontally: more natural position for reading mercury columns, also increasing angle of vision for ease of reading. Rubber grommets insulate thermometer stems and bulbs from all metal parts. Required opening in duct is 8" × $2\frac{5}{8}$": no extra hand hole required for installation or servicing. Bottle holder is designed to take regular "stubby" beer bottle. All parts having contact with the water are treated for corrosion resistance. Where pressure or vacuum of more than $\frac{1}{2}$" of water makes a bottle-fed hygrometer impractical, tap-fed Constant Level Reservoir is available; is adapted for use on any hygrometer; space required for installation, 1" × 8"; height of water in float and wick chambers is adjustable.—*Taylor Instrument Companies, 95 Lines St., Rochester, N. Y.*



Ferrule Terminal Resistors

Ferrule clip terminal type resistors are now available in maker's line of inorganic-cement-coated wire-wound resistors.—*Chemstat Mfg. Co., Inc., 285-7 N. 6th St., Brooklyn, N. Y.*

Low-Voltage Protector Tubes

Designed for indoor service, new gas-filled tube protects supervisory control line wires and telephone lines from over-voltages caused by lightning and direct contact with or induction from nearby power lines. Gaps are in low-pressure inert gas easily ionized and providing a current-carrying path of 50 amps for 2 seconds. Where induction is especially severe, line wires may be continuously grounded through suitable transformers in conjunction with these protectors and all dangerous induction drained off directly.—*Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.*

IMPROVED "SPOTLIGHTS"

Rubicon MULTIPLE REFLECTION galvanometers have recently been much improved through redesign of optical system. The definition of the line-image is now so sharp that readings can be estimated to .1 of a millimeter division.

These sturdy self-contained galvanometers are available with sensitivities as high as 5×10^{-10} ampere and 1×10^{-6} volt per millimeter division.

ASK FOR BULLETIN 320

RUBICON COMPANY

Electrical Instrument Makers

29 North 6th St. Philadelphia, Pa.

Galvanometers, Electrometers, Potentiometers, Colorimeters, Wheatstone & Kelvin Bridges, Resistance Standards, Resistance Boxes, Coil Testers Clip-on Ammeters, etc.

CLOSER TEMPERATURE CONTROL IMPOSSIBLE

Wheelco

CAPACITROL'S

"Radio Principle" completely eliminates time lag in temperature control. $\pm 2\frac{1}{2}$ control for practically any furnace or fuel possible with this instrument. Gives furnace new lease on life and materially increases production and quality of product. Uniquely superior in every detail.

Write for Bulletin No. 204

Wheelco Instruments Co.

1933 So. Halsted St. Chicago, Ill.

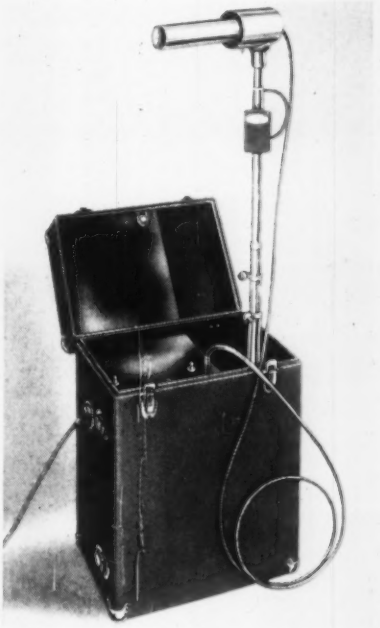
Multi-range Clamp Ammeter

New Bakelite-encased a-c. "Clamp ammeter Model 633" will measure current flow through conductors (insulated or non-insulated) up to $2\frac{1}{4}$" diam. Six scale ranges, 10/25-50-100-250-500 amps., may be selected by range changer located at thumb position. Lower ranges are obtained by passing conductor through split-core transformer (clamping jaws) two or more times. Thus

two turns produce 5 amps. full-scale; four turns, 2.5 amps. full-scale. Instrument is designed to be used at all commercial frequencies, may be used at temperatures from 32 to 110°F. with less than 1% error. Accuracy guarantee of 3% allows for conductor-position error which careful user can eliminate. Design also makes possible remote indication by removing indicator from assembly, inserting it into fixed receptacle in carrying case, and using extension cable. Indicator is maker's "Model 301." Clamp-ammeter has been subjected to voltage breakdown tests of 2,500 volts a.c.; may safely be used on 660 volts a.c. Other features are shatterproof scale glass; slotted end on handle to accommodate strap for hanging on linesman's belt.—*Weston Electrical Instrument Corp., 594 Frelinghuysen Ave., Newark, N. J.*

Dust and Fume Sampler

New Electrostatic Dust and Fume Sampler weighs 25 lbs. complete, operates on 110-120-volt, 60-cycle a.c., employs pre-ionization method for electrostatic precipitation.



Sampling volume rate is 3 ft.³/min.; rate is measured by orifice and manometer employing no liquid. Among features are ability to sample from stacks or ducts, extension tube, aluminum collecting tube permitting determinations by weight, count or chemical analysis.—*Mine Safety Appliances Co., Braddock, Thomas & Meade Sts., Pittsburgh, Pa.*

Now...

QUICK-TEST YOUR TUBES *at Low Cost!* —with New RCA Tube Tester!

Model illustrated (counter type) also available in carrying case for portable use. No. 156, $50.95 Net.

COSTS ONLY **$37.95**

Stock No. 156-A

This splendid new instrument enables you to tell in a jiffy if your tubes are in proper working order. And not only is the RCA Tube Tester amazingly simple to operate... not only does it test all tubes including the new "LOKTAL" types—but it's exceptionally inexpensive, too!

Be sure you're using good tubes! Quick-test them with the RCA Tube Tester—at low cost!

For finer radio performance... RCA Victor Radio Tubes

Listen to the Magic Key, Sundays, 2 to 3 P.M., E.S.T., on NBC Blue Network

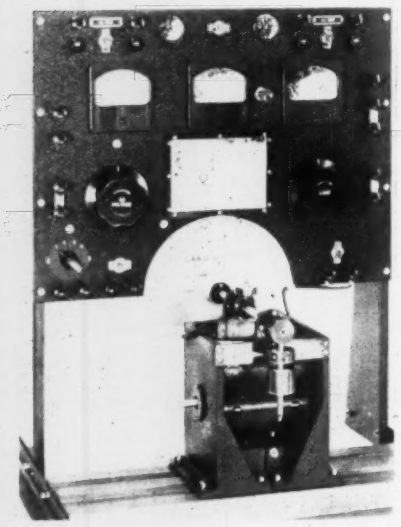
RCA Test Equipment

RCA Manufacturing Co., Inc., Camden, N. J.

A Service of the Radio Corporation of America

Dynamometer

New L.A.B. Dynamometer was designed chiefly for measuring the torque of a motor from stalled torque to zero torque at full speed. With exception of stalled torque, torque is produced by eddy currents in a steel and copper armature, having no



brushes, to avoid friction. Eddy currents are produced by a magnetic field surrounding armature (115 volts d.c., required for this purpose). Torque is read directly on a scale which shows the angular displacement of a known weight at a known radius, without use of springs, so that extremely accurate readings are said to be obtained. "Type 1003" is a universal precision dynamometer for fractional horsepower motors up to 1/10 hp., designed for use on either a.c. or d.c. Torque readings are taken on a center-zero dial of 180° spread to cover both directions of rotation. Readings are directly in oz. in., when using the 2.5-oz. weight at 1" radius, ratio from dynamometer housing to torque arm being 1:1. A 5-oz. weight is also furnished. Both are correct to ± 1 grain. Torque arm has three notches, at 1", 2", and 3" radius. A large number of combinations can be obtained, from 10 to 80 oz. in. Switchboard has input terminals for 115 volts d.c. and 115 a.c. and a d-p. line switch, pilot light and fuses for each. Between lights is mounted a throw-over switch to supply either a.c. or d.c. to the test motor. A separate switch to energize the stator is provided, also a knob marked "Load" by which torque of stator (and thereby load on motor) may be regulated. Connections are provided for use of outside instruments, such as high-precision voltmeter, ammeter or wattmeter. A reversing switch, for motors which are wired for reversing, becomes dead automatically if the selector is set for non-reversible motors.—*L. A. B. Corp., Summit, N. J.*

Test Tube Markers

Made of spring metal with frosted celluloid labels, Fisher Test Tube Marker is easily removed and attached, is permanent, and markings on it withstand ordinary conditions but are readily removed when desired. Particular celluloid employed is not easily burned, does not blacken with heat like paper, withstands ordinary "flaming" of tubes. Writing space is 1¾" wide by 1" high and celluloid label takes pencil or pen markings. Markings will withstand wetting but, with addition of a little soap to a wet cloth, can be washed off. Markers will fit all test tubes of ¾" to ⅞" diam., flasks with necks of these sizes or other containers of this type.—*Fisher Scientific Co., 711 Forbes St., Pittsburgh, Pa.*

'JAGABI' RHEOSTATS MEET *Exacting* REQUIREMENTS

Because they provide fine adjustment and control of electric current over a wide range . . . because they are well made and durable . . . Jagabi Rheostats are selected and used by engineers, educators and research workers—especially those who are influenced by design, quality workmanship and performance. Bulletin 1515-I describes various standard and special types; write for a copy.

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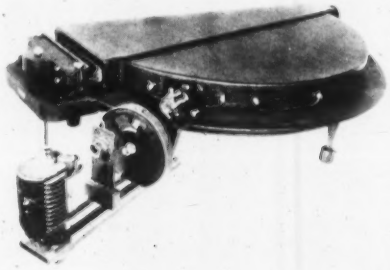
Benzol Indicator

This is a modification of maker's Co[illegible] Inflammable Gas Indicator but 15 times as sensitive; reading to 50 p.p.m. on scale graduated 0-1000 p.p.m. of benzol. Because of sensitivity, water vapor in air would vitiate readings, therefore a dessicator tube is pro-

vided (cartridge lasts 50 to 100 tests), and a benzol scrubber tube (also with replaceable cartridge).—*Mine Safety Appliances Co., Braddock, Thomas & Meade Sts., Pittsburgh, Pa.*

Spectrograph

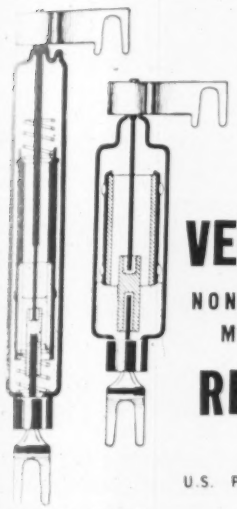
Applied Research Laboratories Spectrograph (*Instruments*, March 1938, page 82) is now furnished with cover and optical bench. Cover allows spectrograph to be operated in a lighted room; a film transfer



case is used to remove exposed film from camera and take it to a dark room. Optical bench is fitted with V groove to insure alignment of rotating sector, lens holder, arc or spark stand, and sector photometer.—*Harry W. Dietert Co., 9330 Roselawn Ave., Detroit, Mich.*

Burette Regulator

Adjustable to stop movement of stopcock plug at its "drop" position and its "flow" position, Fisher's Castaloy Burette Regulator is a metal appliance which can be attached to all sizes of burettes commonly used for titration work, including micro burettes and those of 50 and 100 ml. capacity. It is attached to burette just above stopcock by means of one screw, in such a position that its other screw can be adjusted to impede complete rotation of the handle of stopcock. Adjustment is made so that a full stream flows when handle abuts stop on one side and a slow rate of dropping occurs when handle abuts stop on other side.—*Fisher Scientific Co., 711 Forbes St., Pittsburgh, Pa.*



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COMPACT
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NON-TILTING MERCURY
RELAY

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Normally closed — Normally open

GREAT VARIETY OF MODELS
Normally open and normally closed types
From 10 Amp. to 100 Amp.
Single pole and double pole models
Complete relays or tubes only

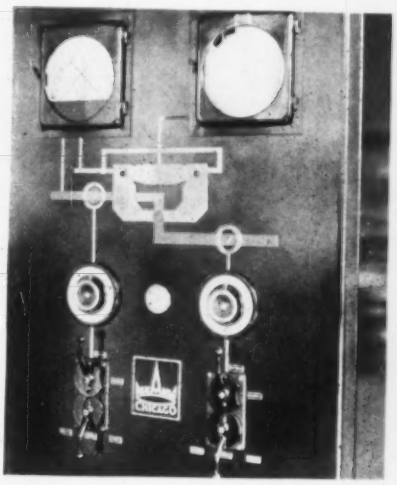
All moving parts completely sealed in glass. No exposed arc. Mercury to mercury contact. Low watt consumption. Noiseless and fast in operation. Space saving. Maintenance free. Operated by concentric solenoid coil.

Electrodes separated by H-shaped quartz body, held in place mechanically without fusion to either glass or metal. Write for literature.

DR. F. LOEWENBERG
10 EAST 40th STREET, NEW YORK CITY

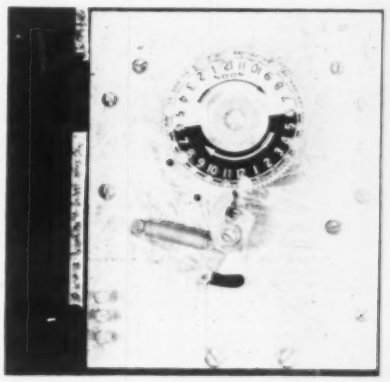
Control Panel Board

Main purpose of this development was to make evident the possibilities of correlating instruments and controls in such manner that "anybody without instruction can operate the furnace." Idea is adaptation of electrical-engineering practice. Illustration shows significant portion of one open-hearth furnace control panel; others panels are being made up for various types of metallurgical and steam-boiler furnaces. *Askania Regulator Co., 1603 So. Michigan Ave., Chicago, Ill.*


Askania Ratio Meter
Gas Flow — Air Flow
Ratio
Recorder
Flue Furnace Pressure
SCHEMATIC LAYOUT OF OPEN HEARTH FURNACE
Lights indicate direction of firing. Strips connect the instruments to the points where signals are taken
Remote Position Indicator Shows butterfly position for air
Remote Position Indication Shows position of flue damper
Ratio Control Adjusting Dial
Oil Pressure Gage
Furnace Pressure Adjusting Dial
Levers For Switch-over From Automatic to Manual
Levers For Switch-over From Automatic to Manual

Adjustable-period Time Switch

New Model 150-B adjustable-period time switch has 24-hour dial so arranged that either "half-hour" or "one-hour" screw pins can be inserted, and equipment operated for any desired periods in steps of, or combinations of half-hours throughout each 24 hours. Cycle can be changed in a few seconds by rearranging the pins. Applicable where a 24-amp. spst d.t. time switch can be used, and a period of not less than one-half hour is desired. *Automatic Electric Mfg. Co., Mankato, Minn.*



ROLLER-SMITH
Announces

the consolidation, as of February 1st, 1939, of its Executive Offices (located prior to February 1st in New York City) with its Works at Bethlehem, Pa. After February 1st all activities of the Company will be concentrated at the new Headquarters at Bethlehem.

The Sales Agencies in New York City and all Principal Cities in U. S. A. and Canada are not affected.

ROLLER-SMITH COMPANY
Electrical Measuring and Protective Apparatus

Makers for *over forty* years of Electrical Measuring Instruments, indicating and graphic; air and oil Circuit Breakers; Switchboards; Rotary Switches; Instrument Transformers.

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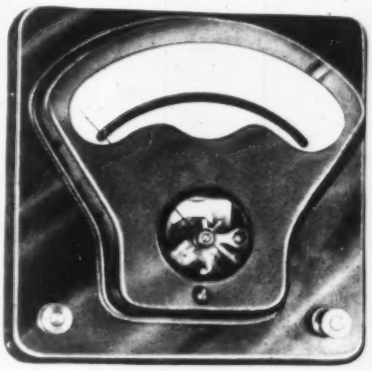
MASTER
PORTABLE INSTRUMENTS
Alternating and Direct Current



Fully Shielded — Accuracy ½ of 1% of full scale—Arc Length 5 inches—Mirror Scale—Attractive black bakelite and metal case—Available in a wide range of capacities.

W. M. WELCH
SCIENTIFIC COMPANY
Established 1880
515 Sedgwick St. Chicago, Ill.

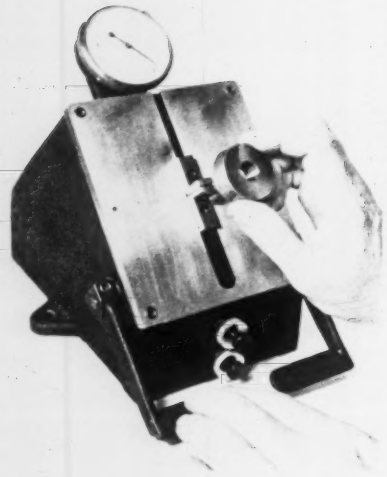
TEST MAGNETIC PROPERTIES OF YOUR STEELS

RAWSON FLUXMETER
SIMPLEST AND MOST EFFICIENT
Bulletin 504

Dynamometers, wattmeters, milliammeters and voltmeters. Also ultra-sensitive meters both for A.C. & D.C., fluxmeters, electrostatic voltmeters from full scale 120 volts to over 20,000 volts, thermocouples, earth current meters, cable testers, etc.

Unquestioned leaders in development of high sensitivity meters

Rawson Electrical Instrument Company
110 POTTER ST. CAMBRIDGE, MASS.
Branch: 15 East 26th Street, New York City
Representative: E. N. Webber
1313 W. Randolph St., Chicago, Ill.



Internal and External Comparator

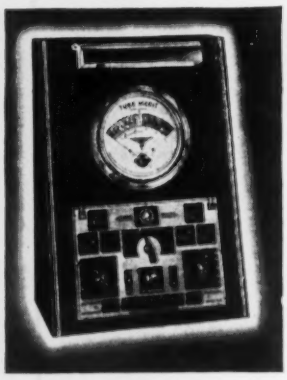
New "Model 36 B-6" checks inside and outside diameters, etc., for size, out-of-roundness, taper and bell mouth. Illustration shows one of three basic methods: two-point contact. Interchangeable plates permit 120° three-point method and reversible 90° three-point method. Contact jaws are available in standard and special forms, interchangeable for different sizes of holes and outside measurements.—*Federal Products Corp., 1144 Eddy St., Providence, R. I.*

Multi-range Tachometer

"S & S Jewelled Hand Tachometer" is a universal hand tachometer designed for measuring speeds over a wide range. Operating on centrifugal principle, it is said to be unique in that it contains eight jewels. Pointer drive is of the increasingly popular type which causes pointer to make two turns around dial, giving readings on two sets of numerals, for inner and for outer scale graduations. Available in two models with ranges as follows: (1) 30-100, 300-1000, 3000-10,000; (2) 25-300, 250-3000, 2500-30,000. Each comes complete in velvet-lined case, with standard accessories.—*George Scherr Co., 128 Lafayette St., New York City.*

"Tube Seller"

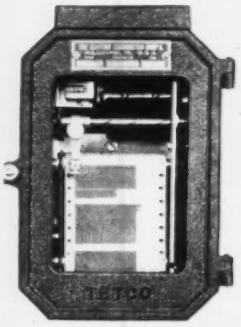
New "Series 815" radio tube tester is push-button-operated, incorporates ballast test facilities, has 9" indicator. Announce-



ment states that "tube selling appeal is developed to its highest point in this display unit."—*Precision Apparatus Co., 821 E. N. Y. Ave., Brooklyn, N. Y.*

TETCO

Speed Recorder

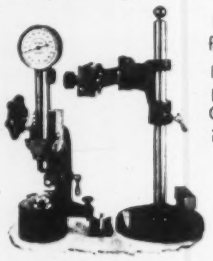


Creates a permanent time record on a waxed chart. Accurately records rate of production, time and duration of stops, total quantity produced.

The Electric Tachometer Corp.
1358 Spring Garden St., Philadelphia, Pa.

HARDNESS TESTING...

done WITH NO MENTAL HAZARDS. The SCLEROSCOPE has done it for the past 30 years.



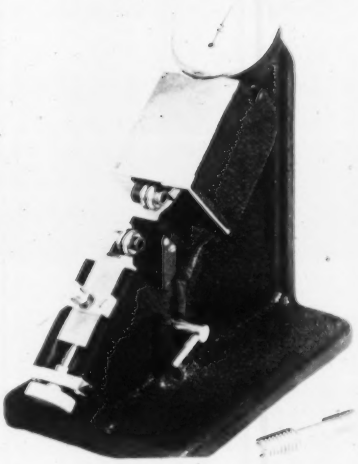
In general use for specification purposes. Simple, sturdy. Comparatively inexpensive.

Illustrated bulletins free.

The Shore Instrument & Mfg. Co., Inc.
9025 Van Wyck Avenue, Jamaica, N.Y.

DESIGNER - SPECIALIST on industrial electric and pneumatic control systems, extensive experience with large instrument manufacturer, seeks new connection. Write Box 106, Instruments Pub. Co., 1117 Wolfendale St., Pittsburgh, Pa.

SEE PAGE 74



Thread-pitch Diameter Gage

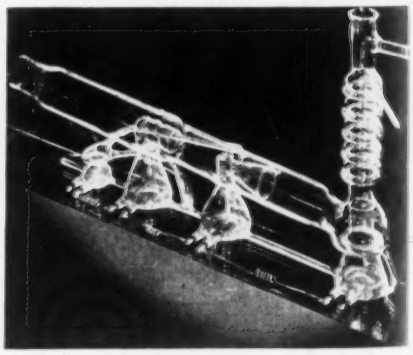
New "Model 45 B-57" has "John-Son" roller contacts, both quickly interchangeable and set for various sizes. In production checking, both of operator's hands are free to handle work. Capacity is 1" standard diam, larger-diam. models available as specials. Height 9¼", weight 15½ lbs.—*Federal Products Corp., 1144 Eddy St., Providence, R. I.*

Ceramic-jacketed Resistors

Ceramic-jacketed fully-sealed non-inductive wire-wound resistors are offered in a range of resistance values up to 3 megohms and in ½, 1, 1½, and 2 watt ratings. Each unit comprises a ceramic spool with a plurality of sections so that the winding can be in reverse direction "pies" for adjacent sections. Resistance wire is impregnated and protected by a ceramic sleeve that slips over the spool. Standard tolerance 1% on all stock items; 0.1% on special order. Terminal styles include wire leads, side lugs, both lugs at one end, etc.—*Clarostat Mfg. Co., Inc., 285-7 North Sixth St., Brooklyn, N. Y.*

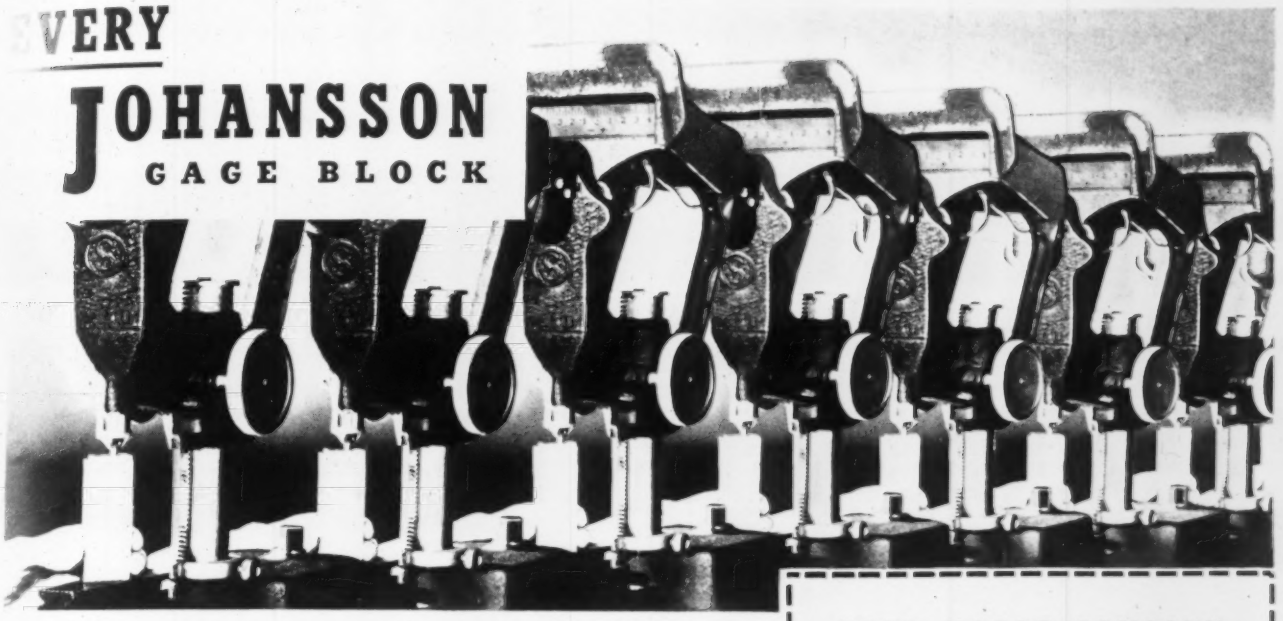
High-vacuum Pumps

A series of high-vacuum diffusion pumps developed by Eastman Kodak Co.'s research labs, includes pumps which effect self-purification of pumping fluid during operation



even when reactive vapors are handled; also high-speed diffusion pumps which operate with air cooling, do not require a cold trap, can produce $<10^{-6}$ mm. at 25°C, and have speeds of 200 l./sec. Illustration shows an all-glass 4-compartment 3-jet fractionating pump with 15 l./sec. speed at 10^{-6}, suitable for 5×10^{-8} mm.—*Distillation Products Inc., Rochester, N. Y.*

EVERY JOHANSSON GAGE BLOCK



Every Johansson Gage Block will pass the U. S. Bureau of Standards. Have them officially inspected and you'll find each block—without exception—well within the limits of accuracy claimed for it. Johansson makes blocks in three degrees of accuracy, priced according to the degree: ±.000008 inch, ±.000004 inch, ±.000002 inch. A set of 81 blocks, accurate within ±.000008 inch, costs only $295. Individual blocks from $3.50. Mail coupon for complete information to keep on hand.

FORD MOTOR COMPANY

Johansson Division, *Dept. D* Dearborn, Mich.

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Pressure Reducing Valves

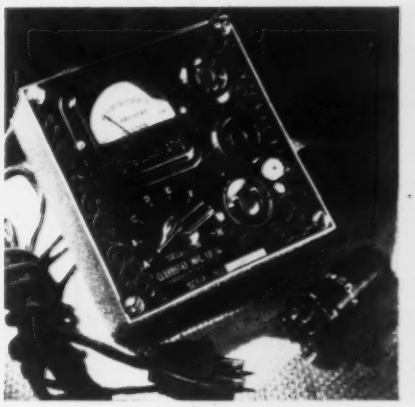
Makers announce a new line of "Copes" valves for steam and water pressure reducing service: "Type DBL" direct-operated, spring-loaded, for controlled pressures from 2 to 50 lbs. Regulation from fully-closed to wide-open under 10% of controlled pressure; not less than 0.5 lb. ¾" to 10" sizes in 125- to 300-lb. pressure standards. "Type DSLH" relay-operated, spring-loaded, for the same pressure limits, will operate with pressure drops as high as 1200 lbs. Regulation is under 5% of controlled pressure; not less than 0.5 lb. 1" to 14" sizes up to 1500 lbs. "Type S-1" a direct-operated, spring-loaded, for controlled pressures from 15 to 250 lbs. Regulation is not more than 10% of controlled pressure; not less than 4 lbs. ¾" to 6" sizes up to 400 lbs. "Type 3-SH-2C" relay-operated, spring-loaded, for the same controlled pressures as S-1, for excess pressures up to 1200 lbs. Regulation under 5%, not less than 2.5 lbs. 1" to 14" sizes to 1500 lbs. "W-DBL" a direct-operated, weight-loaded, for controlled pressures from 27" Hg vacuum to 10 lbs. gage. Regulation is not more than 0.1 lb. ¾" to 10" sizes in 125- to 300-lb. pressure standards. "WS-1" direct-operated, spring-loaded, for controlled pressure limits of 10 to 125 lbs. Regulation not more than 6 lbs. ¾" to 4" sizes in 125- to 300-lb. standards. For remote control of the pressure-reducing station three "Copes Master Controls" cover a controlled pressure limit of 2 to 600 lbs. gage. Regulation from fully-closed to wide-open is not more than 5% of the controlled pressure; not less than 2.5 lbs. Two relay-operated, spring-loaded valves are used with these controls: "R-DBL" 1" to 10" sizes in 125- to 900-lb. standards, for moderate pressure drop across the reducing valve; "R-DSLH," 1" to 14" sizes and 125- to 1500-lb. standards, operates with pressure drops as high as 1200 lbs.—*Northern Equipment Co., Erie, Pa.*

Multi-range Ohmmeter

New "Model 763" ohmmeter has ranges from 0.2 up to 300 megohms, can be used on top range as a modified "megger" wherein 125 volts (maximum current 50 microamps) is available for insulation tests. Sensitivity of 50 microamps for full-scale deflection permits resistance measurements in circuits where measuring current must be minimal; leakage on capacitors having resistances of approx. 300 megohms. Line voltage control permits operation from any 60-cycle circuit with a voltage between 105 and 130. Test circuit is entirely isolated from a-c. line to prevent shocks to user when external leads are employed. Rectifier tube supplying 125 volts needed for 300-megohm range is said to have characteristics that permit instantaneous readings. Both jacks and binding posts are provided, the jacks may be used with elbow terminal type leads supplied with the instrument.—*Weston Electrical Instrument Corp., 591 Frelinghuysen Ave., Newark, N. J.*

Resistor Tester

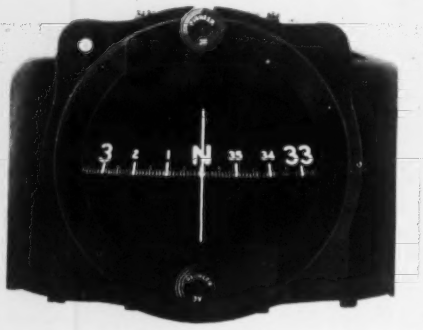
For testing resistor tubes and line-cord resistors, new steel-cased "Model 160 Tester" has panel carrying indicator, prong-selector switch and sockets for testing resistor tubes with any type of base. Also receptacle for plugging in a resistor line-cord; pin jack for testing different cord leads; eight-position selector switch per-



mitting indicator to be cut in on any prong of a resistor tube being tested. Dimensions 5¼" × 5¾" × 2". *Chirostat Mfg. Co., Inc., 285-7 N. 6th St., Brooklyn, N. Y.*

Magnetic Compass for Aircraft

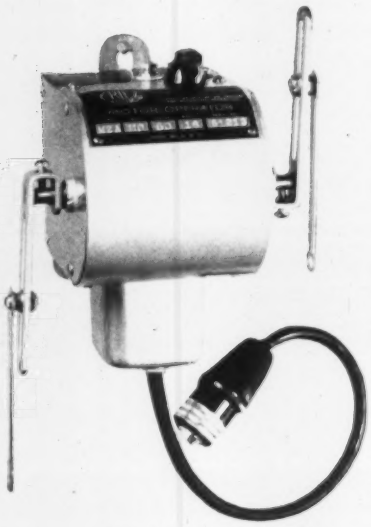
New magnetic pilots' compass is somewhat similar to Air Corps model B-17 but has been designed especially for use on commercial and private airplanes. It includes many features of maker's "1808" and "1809" aperiodic type navigators' compass. Side of card carries azimuth gradua-



tions in 1° intervals and is visible through window which magnifies card and fixed vertical lubber line. To achieve stability and freedom from northerly turning and acceleration errors, card is mounted in a "moderately large" bowl and has damping period somewhat longer than that of the "1808." To assure satisfactory operation under vibration, pivot rests on a jewel mounted in a cushioned post. To permit operation under all conditions of temperature and pressure, provision is made for liquid expansion and contraction. Glareless illumination is by a "Pioneer Ringlite."—*Pioneer Instrument Co., 75½ Lexington Ave., Brooklyn, N. Y.*

Damper Motor

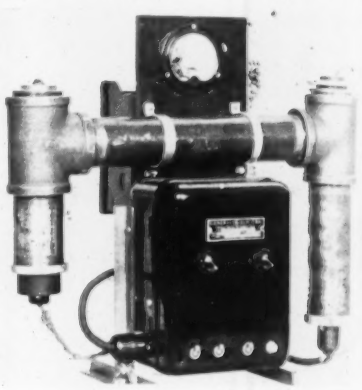
New Friez Motor Operator gives effect to automatic control provided by thermostats and other instruments without recourse to



electrical relays; is used on low voltage furnished to control circuit and motor by secondary of a transformer (supplied with each motor) from 110- or 220-volt a.c.; is fitted with an auxiliary hand switch giving manual "on," "off" or "automatic" positions; also with adjustable arms for connection to the dampers. Eight types available; for 3-wire or 2-wire applications, with built-in or separately mounted transformers and various accessories.—*Julien P. Friez & Sons, Baltimore St. & Central Ave., Baltimore, Md.*

Mercury Vapor Detecto

Improved model employs resonance [illegible] tion method as did first model *(Instruments* Nov. 1933, page 211) but is simpler, [illegible] sensitive; to one part of Hg in 10⁹, quicker in operation and composed of readily-available tubes, etc. Ultra-violet lamp and photo-



tube are mounted at opposite ends of a short length of 2" standard pipe through which sample is drawn. An amplifier vacuum tube is mounted in same housing as phototube. Illustration shows indicating detector. A recorder can be installed in place of the indicator and can be supplied with a limit switch, alarm relay circuit, etc. Furthermore, it is possible to locate absorption chamber several hundred feet away and operate it remote-controlled. New detector requires about 100 watts to operate, and plugs into the ordinary a-c. outlet. Portable commercial unit will weigh about 100 lbs. and measure 10" × 18" × 21".—*General Electric Co., Schenectady, N. Y.*

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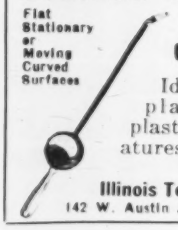

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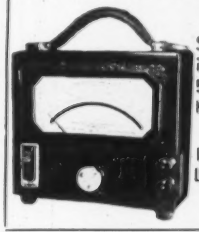

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...chrometer" employs new method for ...g position of disks, which is said to ... with sources of error such as wear ... and mechanical parts used to change ...n of disks in conventional type of

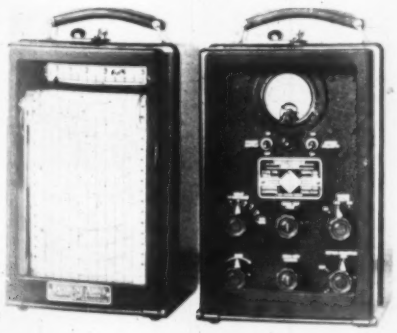
photometer. New instrument consists essentially of two disks, each attached to shaft of a separate synchronous motor, and both coaxial. One motor is fixed to stationary frame of instrument; the other may be rotated. Since both motors run synchronously, any change in angular position of rotatable motor results in corresponding change in relative position of disks. Arrangement thus permits continuous variation of transmittancy from zero to maximum during operation. There being no light-absorbing optical system in light-path, efficiency of transmittancy is maximized.—*Frahm-Faybar Co., 5612 Prospect Ave., Cleveland, Ohio.*

Humbucking Transformers

Two new telescopic-shielded humbucking transformers are announced: Type P-202 is designed for a multiple-line primary of 500-333-250-200-125/50 ohms and secondary of 50,000 ohms (single class "A" grid) having a frequency response of ± 2 db, 60-10,000 cycles, shielding 90 db, mounted in 4 high-permeability steel cases. Type T-6 is designed with a primary of 200 ohms and secondary of 20,000 ohms (single class "A" grid) having a frequency response of ± 3 db, 60-10,000 cycles, shielding 50 db. Both units are 2½" × 2" × 2⅞" high.—*Kenyon Transformer Co., Inc., 840 Barrm St., New York City.*

D-c. Amplifier

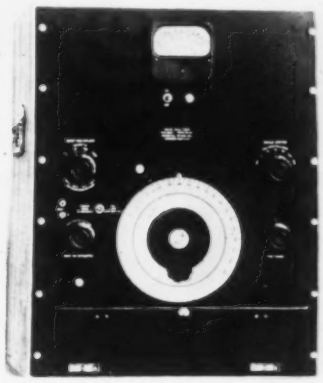
Designed mainly for use with recorders in industrial applications, Type 715-A Direct-current Amplifier has also laboratory uses. Applications include amplifying to usable levels the small d-c. voltages obtained from photoelectric cells, resistance thermometers, sound-level meters, etc. In conjunction with recorder it can be used as a recording d-c. milliammeter or millivoltmeter. Four ranges are provided, giving an output of ½ milliamps into a 5000-ohm load



for input voltages of 0.1, 0.2, 0.5 and 1.0 volt, respectively. Maximum gain, expressed as a transconductance, 50,000 micromhos. Amplifier operates from a-c. line, is essentially unaffected by changes in line voltage or in ambient temperature, is available in a walnut cabinet or in an Esterline-Angus recorder case as shown. Net weight, 26¼ lbs.—*General Radio Co., 30 State St., Cambridge, Mass.*

A-c.-operated Wave Analyzer

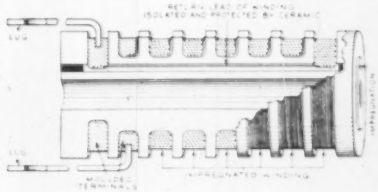
New Type 736-A Wave Analyzer is a heterodyne type of instrument similar in principle of operation to maker's Type 636-A but having greater sensitivity, greater voltage range and increased convenience of operation. Principal feature is a broad-band



flat-top i-f. filter using three quartz bars operating at 50 kc. Pass band is 4 cycles wide at top; response is down 15 db at 5 cycles. Normal input impedance is one megohm. A 100,000-ohm potentiometer is provided as an alternate input system. Other features: complete a-c. operation, linear scale, self-contained calibration means, high input impedance and freedom from humidity effects. Approx. dimensions 20" × 25" × 11"; net weight 85 lbs.—*General Radio Co., 30 State St., Cambridge, Mass.*

Resistors with End Terminals

Three new types of "IRC Precision Wire Wound Resistors" have both terminals brought out at one end, thus minimizing shorting and breakage of terminals. Base is so designed that resistance wire is returned internally through the ceramic, yet insulated



and protected from windings or mounting bolts. End leads of resistance wire are not exposed. Standard tolerance is 1%; tolerances up to 0.1% on special order.—*International Resistance Co., 401 North Broad St., Philadelphia, Pa.*

Glass-sealed Attenuators

New fixed attenuation pad is hermetically sealed in a glass tube, can be furnished to match the impedance of any line and give any desired db loss from 0.25 up to 40 db or infinity. It is built like a radio tube and provided with Bakelite tube base for mounting in tube-type sockets. Though offered as an "H" pad, new attenuator can also be provided as a "Pie," "T," or "L" pad. Units are made to order.—*Ohmite Mfg. Co., 4835 Flournoy St., Chicago, Ill.*

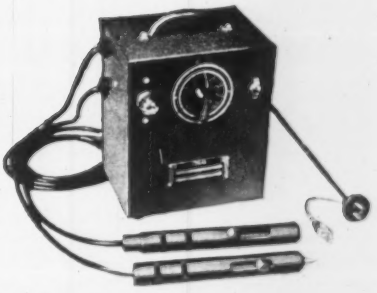
Production Counters

New series of counting machines includes twenty models, known as Series H Productimeters, they are said to require no attention or maintenance as all shafts run on

oilless bearings of automotive-industry type. They are available in stroke or rotary models; non-reset, wing nut reset, or tumbler lock reset; operating levers on left or right; shaft extensions on left or right, or both ends; five or six figures; rotations clockwise or counter clockwise. Unauthorized resetting is prevented, where desired, by models carrying tumbler locks permanently fitted to the shaft.—*Durant Mfg. Co., 1940 N. Buffum St., Milwaukee, Wis.*

Insulation Tester

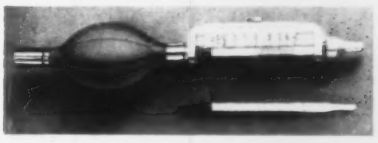
New insulation tester tests up to 2,500 volts, indicates, in about a second whether or not there is a short, ground or broken wire, is especially suited for testing insula-



tion of low-voltage equipment. In addition to insulation of all current-carrying parts, safety features include a three-wire primary cord, spring-operated cover over high-potential secondary test points, and a red indicating lamp.—*Ideal Commutator Dresser Company, 1520 Park Ave., Sycamore, Ill.*

Hydrocyanic Gas Detector

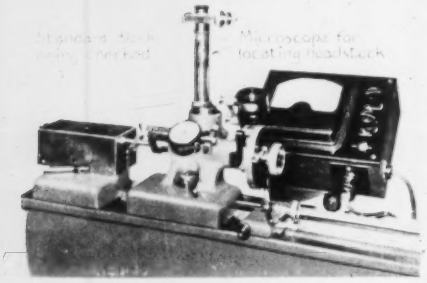
Consists essentially of aspirator bulb, prepared detector tube, and movable scale graduated to read directly in percent of HCN. In operation, bulb is squeezed to draw sample of atmosphere through detector tube into bulb and force analyzed sample out other end of bulb. Detector tube



contains a granular chemical between two plugs of glass wool. Surface of granules reacts with any HCN present in sample and turns blue, beginning at end where sample enters. Length of travel of this coloration is proportional to percent of HCN gas in sample; concentration can be read directly to be read on scale which is calibrated to show concentration with ten squeezes of bulb.—*Mine Safety Appliances Co., Braddock, Thomas and Meade Sts., Pittsburgh, Pa.*

Electrified Measuring Machine

Millionths-of-an-inch differences can be compared electrically through combination of new G-E gage head and Pratt & Whitney measuring machine originally built to measure mechanically to 0.00001". Differ-



ences in length over 0.00001" are measured mechanically at headstock; millionths by combination of tailstock and new electric gage which is used also in setting pressure on gage standards being checked. Before application of electric gage, accuracy depended on ability of operator to judge pressures on gage standards being measured between headstock and tailstock spindles. Now, electric gage-head is mounted on tailstock in such a way that gage spindle is tailstock spindle, thereby producing responsiveness to variations in gaging pressure. *General Electric Co., Schenectady, N. Y.*

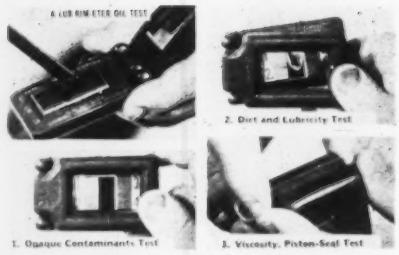
Supersensitive Comparator

Special indicator on new "Model 110 B-3" has been designed for unusually high sensitivity, its zero-center scale having a range of 0.002", also for "repetition" properties.

Spindle friction is eliminated by a spring bellows support arrangement. Instrument as a whole is suitable for gage-checking and other precision work. Vertical capacity, approx. 1½"; horiz. clearance to slide, approx. 2½". *Federal Products Corp., 1144 Eddy St., Providence, R. I.*

Crankcase Oil Tester

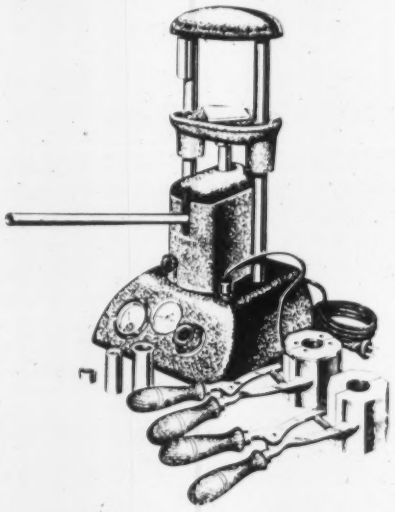
"Lub-rim-eter" is a device for ascertaining condition of motor oil. Procedure (ref. to illustrations): (1) Draw bayonet gage from crankcase, touch tip to central groove in lens and let 6 or 7 drops run in groove. (2) Close wings, hold to light, look through lens and compare shade of oil sample with four standards constituting opaque-contaminants scale: "clean," "fair," "poor," "bad." (3) To make "dirt and lubricity test" spread oil sample over flat surfaces of lenses, press lenses together and rub them



back and forth over each other to ascertain presence of grit, dirt and hard carbon. (4) To make "viscosity, piston-seal test" press lenses together tightly with sliding motion then slowly pull them apart and watch action of oil: hard pull means "good," no adhesion means "bad." It is said that entire procedure of four tests can be made in less than 60 seconds. *Inspection Machinery Co., 5511 Euclid Ave., Cleveland, Ohio.*

Specimen Mounting Press

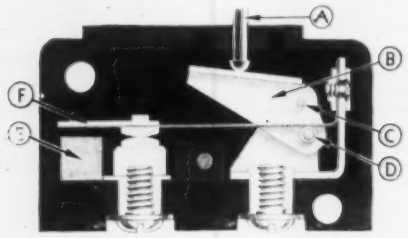
Designed for mounting specimens by polymerization of duPont Lucite (methyl methacrylate) through application of controlled heat and pressure, Fisher Specimen Mounting Press is operated by hydraulic system



exerting up to 5000 lbs. pressure—against hardened and ground piston within steel cylinder that holds sample and thermoplastic. Mounts 1" in diam. and up to 1¼" high are produced. *Fisher Scientific Co., 711 Forbes St., Pittsburgh, Pa.*

Snap Switch

The switch action originally developed as a feature of maker's low water cut-offs (*Instruments*, May 1935, page 133; Sept. 1936, page 248; Oct. 1937, page 253) has been made the basis of a snap switch now available in various types for manufacturers. It is claimed to combine quick make or break



with a wide air gap, low operating pressure and short-travel operation. Plunger A acts on lever B pivoted at C so that roller D lifts spring F on which one of contacts is mounted. Iron armature at end of F is attracted to the "Alnico" permanent magnet E, which holds switch in contact until pressure on spring overcomes magnet pull, at which point characteristic of a magnetic field spring instantly "kicks" to its limit. When closing, action is said to be similarly instantaneous "when spring is within influence of permanent magnet. Design thus provides for wide air gap with large contacts despite size of switch: 1⅛" x 1⅝" x 1 11/16". As a result, switch will operate on both d.c. and a.c. Types are available with operating pressures as low as ¼ oz. to as high as 12½ oz. Plunger movement may be as short as 0.005" to as long as 0.014". Switch illustrated is the single-normally-closed; also made in normally-opened, s.p.d.t., etc. *McDannell & Wright Bldg., Chicago, Ill.*

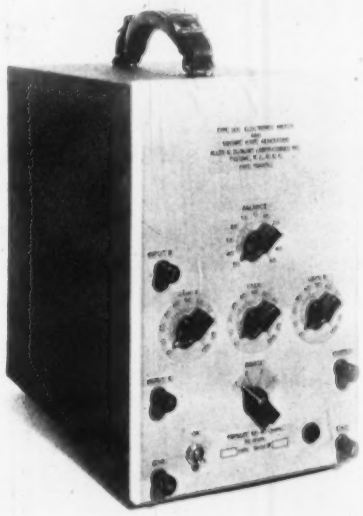
Unit Bins

For keeping track of screws, bolts, nuts, fuses and other small parts required in maintaining and servicing instruments, etc., "Add-A-Bin" is a system of unit bins sold separately and assembled by the user to fit

his individual needs. Bin housing may be screwed to a vertical surface, or to a panel which may be fashioned into a portable kit. Each bin is so balanced that weight of contents makes it close when hand is removed; each locks open if lifted slightly when open; or it may be lifted higher and pulled out and down for cleaning; or it may be removed entirely. *Naugle Products Co., 130 Adair, Mich.*

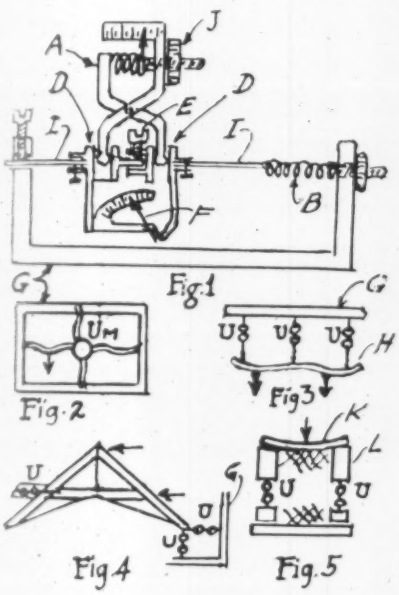
Electronic Switch and Square-wave Generator

"Type 185 Electronic Switch" is a modification of "Type 150" (*Instruments*, Dec. 1935, page 345) and it may also be used as a square-wave generator between 60 and 100 cycles per second. *Allen B. DuMont Labs., 2 Main Ave., Passaic, N. J.*



ress Measuring System for Structures

design of complicated structures models are essential, new device as Stressometer is said to be the instrument which measures stresses ments directly on dial of test scale 1). Works on principle that when ber under stress is broken it will as much force to bring broken ends ther again as there was stress in the Fig. 1 is diagrammatic elevation trument, showing rod *I* being pulled spring *B* with a force of say 15 lbs. *E* "breaks" rod when turned and like test scale *A* brings broken ends ther again when nut *J* is turned, and nsion of test scale spring as recorded dial above it measures the 15-lb. force essary to bring such ends together. Thus,



test scale will measure stress in rod *I*. To enable members under stress to be broken or cut, units *U* are interposed within members under stress, as indicated in Figs. 2 to 5. Unit *U*, shown in fuller detail in Fig. 1, consists of tubes *D* into which the ends of test scale may be inserted, such tubes being held together by screw *E*. When *E* is turned, tubes move together or apart and movement may be noted on strain gage dial *F*. Then nut *J* is turned till *F* reads zero as at start before screw *E* was turned, at which time the test scale reading is a measure of stress in member. In Fig. 2 a special unit U_0 interposed at junction of four bars subjected to bending permits measuring bending moment at the end of each bar at junction. In Fig. 3 units *U* are interposed along supports of continuous beam *H* suspended from frame *G*, permitting measurement of the reactions. In Fig. 4 units are placed so that reactions of truss and the stress in one of its members may be measured. Fig. 5 shows beam *K* supported both by soil beneath it and by foundation piers *L*; units *U* so attached that portion of force on beam taken by piers may be measured. Stressometer serves also for demonstrations to engineering students, being the only structural-laboratory instrument for illustrating theory of framed structures.—*Morris Berman, Asst. Engineer, Dept. of Housing & Buildings, City of New York, Borough Hall, Long Island City, N.Y.*

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Magnet *Established 1924* Solenoid

Electrical Coil Winding Co.
2736 Saunders St., Camden, N. J.

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POWERS

45 YEARS OF TEMPERATURE AND ★ HUMIDITY CONTROL ★

A New Temperature-measuring Method —the Solubility Thermometer

By J. C. WITT
Chemical and Mechanical Engineer, Chicago, Ill.

SOME years ago the writer observed that a solution of paraffin in carbon tetrachloride (prepared from ordinary materials, without particular care, for industrial use) behaved rather oddly: A small bottle of this solution had been standing for several months in the office building of a large industrial plant. It was clear most of the time but, during winter months, appeared to be solidified on Monday morning, gradually becoming clear in the afternoon and remaining clear until the next Monday morning.

Upon investigation, it was found that when the solution was cooled to approximately 74° F., a quantity of the paraffin crystallized out rapidly. The quantity of crystals was sufficiently large to give the whole contents of the bottle the appearance of a light-gray translucent solid. There was no evidence of supersaturation or delayed crystallization. Some of the solid phase, examined under the microscope, was found to consist of well-formed crystals.

Inquiries revealed that during the week-end the temperature in the office building was lowered. It was apparent, therefore, that at some time during that period, the temperature of the solution had been lower than 74°. The solid phase remained for a few hours after the temperature had risen, but gradually disappeared—a clear solution again resulting.

Observation of the paraffin solution called to mind that the number of methods employed for measuring temperatures has been growing since the days of Galileo. In 1930 Béhar listed[1] some eighteen methods. Since then there have been reports of methods utilizing changes in color.[2] To Dr. Edwin B. Frost, formerly Director of Yerkes Observatory, we owe a unique method: He had observed changes in the pitch of a cricket's chirp and wondered what brought them about. He found that frequency varies directly with temperature, and developed a formula showing this relation.[3]

Five solutions of various concentrations of paraffin in carbon tetrachloride have been prepared. Paraffin crystallizes out at temperatures of 90, 80, 70, 60, and 50°F., respectively. These solutions have been used for obtaining some preliminary information on the characteristics of what may be called a solubility thermometer.

If the series of solutions is at 95°, and the temperature falls to 45°, each solution in order becomes translucent. At any intermediate point the temperature may be read to the nearest ten degrees. If the temperature then rises to 95°, the solutions become clear—in the reverse order. There is some lag in the change from translucent to clear, however. Time is required for the transfer of heat from the exterior of the container to the center of the solution, for diffusion and for dissolving the paraffin. It is planned to study these factors to determine to what extent the lag can be reduced. As constructed at present, the thermometer may be classed as a multiple minimum-temperature thermometer.

No reason is apparent why the temperature interval cannot be reduced to a fraction of one degree. It seems likely that the range of the thermometer is limited only by the vapor pressure and the freezing point of the solvent, by the nature of the solubility curve, and of course by the physical characteristics of the material of which the container is made. Probably other satisfactory combinations of solvents and solutes could be found—although it is believed that there are relatively few of them. No reference on the solubility of paraffin in carbon tetrachloride has been located, but Sakhanov and Vassiliev present some data on the solubility of paraffin in other solvents.[4]

It is unlikely that the solubility thermometer will provide much competition for thermometers filled with mercury and other liquids. However, it has many unique characteristics which suggest its value in the manufacture of novelties and for some industrial uses. Some of these characteristics are listed and discussed briefly as follows:

(1) A mercury thermometer consists of a bulb, and a relatively long stem bearing a scale. The scale reading indicates the temperature of the mercury in the bulb, with or without the application of a correction factor. Each unit of a solubility thermometer indicates the temperature at the point observed, or the mean temperature for the entire length of the unit, depending on conditions. This permits the manufacture of units in a wide range of sizes and shapes, including hollow beads and cylinders, and the mounting of any number of these. The units may be large, so that they may be read at a glance, at some distance; or they may be small, for combined decorative and utilitarian purpose. It is probable that colored substances may be added to the solvent to provide novelty and improve visibility.

(2) After a solution has been prepared, standardized, and sealed in glass containers, each unit should remain constant indefinitely. It is unaffected by vibration, dust, contamination of any kind. It is available for temperature measurements or for standardization.

(3) One unit of a crystallization thermometer is convenient for indicating whether a temperature is above or below a given point. Two units may be employed to show that a temperature is between two fixed points. Such information may be obtained at a glance, without reading a scale. Many applications have suggested themselves, and there seems to be no limit to the number that could be made.

(4) It is probable that the solubility thermometer can be utilized for automatic devices of various sorts. For example, if a unit were placed between a source of light and a photo cell, a signal or some regulating device could be actuated.

Patent proceedings are under way.

[1] *Instruments*, Vol. 3, 1930, pages 161-162.
[2] *Instruments*, Vol. 10, 1937, pages 65 and 209.
[3] *Chicago Daily News*, November 30, 1931.
[4] Petroleum. *Zeitschrift fur die acsamten Interessen der Mineralol-Indus-trie und des Mineralol-Handels*, Vol. 21, 1925, page 735.

Temperature Symposium

(Preliminary Notice—more in March *Instruments*)

A symposium on "Temperature, its Measurement in Science and Industry," broadly covering many fields of science and engineering, will be held under auspices of the American Institute of Physics, 175 Fifth Avenue, New York City, next Fall.

An advisory committee has been formed consisting of: *Chairman*, C. O. Fairchild, C. J. Tagliabue Mfg. Co.; Dr. E. F. DuBois, Russell Sage Institute of Pathology; Dr. Gustav Egloff, Universal Oil Products Co.; Dr. John Johnston, U. S. Steel Corp.; Dr. Walter G. Whitman, Massachusetts Institute of Technology; Dr. H. A. Barton, American Institute of Physics.

Those interested in contributing to this symposium should communicate with the Institute at an early date.

New York, Feb. 7, 1939.

"Temperature Measurement and Control"

Revision of this book was begun when the first edition (1932) became exhausted in 1935, is being carried forward. Persons desiring the inclusion of subjects in which they are interested are asked to write to the author, M. F. Behar, 245 Melwood St., Pittsburgh, Pa.

A Method of Dimensional Gaging with Photoelectric Cells

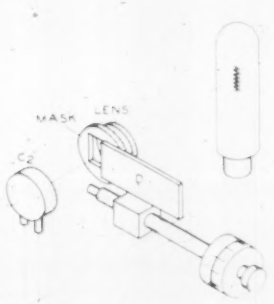
By CLIFTON TUTTLE and WILLIAM BORNEMANN
Research Laboratories, Eastman Kodak Co., Rochester, N. Y.

Communication No. 796 from the Kodak Research Laboratories.

OPTICAL gages of the interferometer or the projection-microscope type and mechanical caliper gages are all indispensable industrial tools but—like most other commonly-used high-precision dimensional gages—they suffer from some limitations. Interferometer gages, for instance, are difficult to set up and tedious to use. With projection microscopes, the higher the magnification, the more delicate the adjustment of the focus. Moreover, at high magnification the diameter of the working field is so limited that unimportant irregularities along the edges of the sample to be measured may occupy the entire visual field, so that the measurement may not be significant of the true dimension. This, of course, is generally true when the average distance between edges of considerable length is required.

Readings obtained with most of the mechanical gages are to some extent dependent upon the pressures applied at the caliper jaws and this is troublesome if the article to be measured is fragile or flexible.

The readings of most of the available high-precision gages are not easily recorded by automatic methods nor can they be readily used in the automatic control of the process by which the measured article was manufactured.

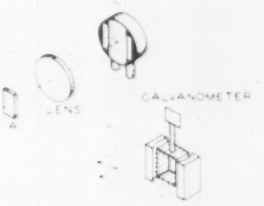


It seems probable, therefore, that there might be a number of applications for the method of photoelectric gaging which will be described here. A gage can be set up easily, using commercially available equipment in its construction, and the optical adjustments are not critical. The principle can be readily applied either to automatic inspection, in which articles are rejected when they fail to come within predetermined dimensional tolerances, or to fully-automatic dimensional recording of articles of any sort, provided that they can be moved to and from the measuring station mechanically. In some cases, a reading of the gage might be used to influence the manufacturing process so as to rectify dimensional errors automatically.

Photoelectric Photometry Applied to Gaging

The photoelectric instrument applies a photometric measurement to the gaging problem. To state the principle briefly, the article to be measured is used as a diaphragm[1] in an optical system which illuminates the photocell, and the cell output, since it is proportional to the total flux which it receives, can be interpreted in terms of the light-stopping power and, hence, the dimensions of the object. If the nature of the object whose dimensions are to be determined is such that it cannot be used as a diaphragm in a beam of light, as would be the case of a transparent article, it sometimes is possible to use a type of mechanical-optical calipers which will be mentioned later.

The photometry involved in precision gaging must be carried out with a higher degree of accuracy than that required in most other photometric problems. It therefore is fortunate that one of the most accurate methods of photoelectric photometry is one which may be readily applied to the problem of gaging. It has been shown[2] that two barrier-layer photocells connected with opposed potentials across a galvanometer are capable of indicating equality of illumination of the beams striking both of them, with a precision of better than 0.1% and, furthermore, that the continued stability of this circuit may be relied upon.[3]



A great variety of optical arrangements may be devised for the purpose of directing two light beams onto two photocells, but the various arrangements that are adapted to gaging purposes are essentially modifications of one of two different principles.

In the first and simplest arrangement, the article to be measured diaphragms the beam to one cell and the other beam falls on a second cell which merely monitors the light source. This arrangement is illustrated schematically in Fig. 1, which shows a method of gaging the width of an article, *A*. An image of the article is formed on cell C_1. The position of the image is indicated in the drawing by diagonal cross-hatching, the solid black portion shows the location of a rectangular opaque mask, and the portions of the cell left uncovered by both mask and image, *i.e.*, the illuminated portions, are left white. The output of cell C_1 is opposed to that of the second cell, C_2. This cell, C_2, which monitors the light source, will be called the comparison cell, and C_1, which inspects the article, will be called the measuring cell. A balance in photoelectric output of the two cells is effected by sliding a movable diaphragm, *D*, in the comparison beam. The state of balance is indicated by a null reading of a galvanometer in the cell circuit and the position of diaphragm *D* at the moment of balance is a measure of the dimension of the article. A narrower article will, of course, leave a greater portion of the measuring cell uncovered and a wider opening of the comparison cell diaphragm will be required to establish a balance.

In the second optical arrangement, both beams become measuring beams and both cells become measuring cells. This method is illustrated in Fig. 2, which is a setup to measure the pitch of a gear wheel or a toothed rack. The images of two left-hand edges of adjacent gear teeth are projected onto two cells. At some value of the pitch, the projected images of the adjacent teeth will leave uncovered equal widths of the illuminated areas on both cells.

[1] It is immaterial whether this "diaphragm" in the optical system is located so as to change the intensity or the area of illumination of the photocell. It might, for example, lie close to the plane of a lens arranged to focus the image of a light source on the cell. In this case, a dimensional variation of the diaphragm would alter the intensity of the image illumination. Alternatively, the diaphragm might be located near the sensitive surface of the cell itself, and, because of a variation of the diaphragm dimension, a larger or smaller area of the cell surface would be illuminated.

[2] H. A. Beyer, A Compensating Circuit for Blocking-layer Photoelectric Cells, *Review of Scientific Instruments*, Vol. 8, 1937, pages 279-285. (This paper contains a bibliography of other publications on compensating circuits.)

[3] C. Tuttle, A Recording Physical Densitometer, *Journal of the Optical Society of America*, Vol. 26, 1936, pages 282-292.

The principle of the gage requires that equality of cell response shall occur whenever these widths are equal. Slight inequalities in the sensitivity of the two cells or in the intensity of illumination falling on the two sensitive surfaces will prevent the realization of this condition but the relative lengths of the two uncovered slits of light may be altered by sliding an opaque mask over the cell of highest output so as to produce equality of response. If, after this adjustment is made, a second pair of teeth of different pitch is indexed into the measuring position, the balance will be upset. The galvanometer deflection may be restored to zero by moving one of the cells closer to or farther away from its neighbor until the equality in width of the illuminated areas is reestablished. The extent of this movement divided by the optical image magnification gives the magnitude of the difference in pitch.

It should be noted that, within wide limits, the accuracy of the measurement is not influenced by the accuracy with which the article is registered in the beam in the case of either Figs. 1 or 2. If, for instance, object A in Fig. 1 is displaced either to the right or to the left, the image on the cell will shift correspondingly, but, if the edges of the image are not shifted beyond the confines of the rectangular opaque mask, the total illuminated area of the measuring cell will remain constant.

Again, in Fig. 2, inaccuracy in indexing successive pairs of gear teeth into the measuring position will still result in equal widths of the illuminated areas of C_1 and C_2 if the pitch is correct.

A system like that of Fig. 2, wherein both cells act as measuring cells, cannot be utilized so easily to measure the distance between right and left-hand edges of an object, unless the object can be perfectly registered in the measuring position. It is apparent that an error in registration will uncover a greater width of illuminated area on one cell, and a smaller width on the second cell. The resultant change in relative cell outputs would, of course, be interpreted as a dimension change.

It may sometimes happen that the system illustrated in Fig. 2 may be the most convenient for gaging the distance between right and left-hand edges of an object. In this case, to avoid the necessity of accurate indexing of the measured object into the measuring system, one has recourse to the method illustrated in Fig. 3. Here, instead of the object itself becoming a diaphragm in the optical system, opaque vanes attached to caliper arms are used to diaphragm the beams—the separation of these vanes being dependent upon the object dimension. This scheme sacrifices some of the advantages of the method in which the object itself is used as the optical diaphragm and is, in general, subject to the errors of any mechanical measuring device. The pressure necessarily applied to the gaging points might distort a fragile sample, or edge irregularities might give rise to misleading readings.

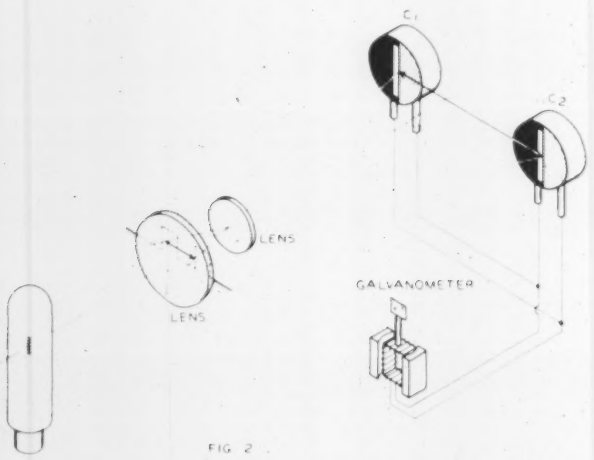


FIG. 2

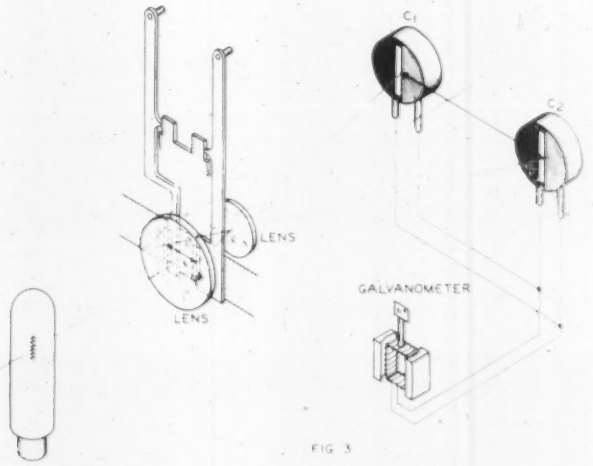


FIG. 3

Optical Magnification in a Photoelectric Gage

Figs. 1 and 2 show enlarged images of the sample projected onto the photocells. Actually, optical magnification is not a requisite of the photoelectric gage. Optical reduction, instead of magnification, may be desirable in some cases, and, in other cases, the object to be measured might be placed close to the cell surface with no intervening optical imaging system. This latter arrangement is in fact the more desirable from the point of view of photoelectric sensitivity, for it is the arrangement in which a given variation in an object dimension will produce the largest variation in light flux striking the cell.

Any system for imaging the object on the cell, whether it is by magnification or by reduction, will result in some loss of light flux. An imaging system of some kind is, however, usually dictated by mechanical considerations. For example, it may be difficult to move the sample into a measuring position in close proximity to the cell or it may be difficult to cut a fixed aperture of the proper size and shape for the photocell surface, whereas this problem may be simplified if the fixed aperture is placed in the plane of an enlarged image.

In general, it is desirable to choose a magnification or reduction such that a considerable length of the image of the boundary lines of the article can be effective in the measurement. The ability of the photocell and its associated optical system to give an average reading of the distance between two irregular edges constitutes one of the advantages of the photoelectric gage over both the conventional contour projector and the mechanical caliper.

Accuracy of the Method

The accuracy attainable in a photoelectric gage of this type seems to be fundamentally dependent upon the precision with which the null point, or point of equality of output of the two cells, can be determined. The practical factors which determine this precision are the amount of photoelectric change which a given dimensional change can produce and the sensitivity of the galvanometer. The magnitude of the photoelectric change depends upon the amount of light flux which can be passed through the aperture in the optical system and upon the sensitivity of the photocell.

If a gage is to be read visually and if rapid reading is not essential, a high-sensitivity galvanometer may be used. There then seems to be no definite limit to the gaging accuracy imposed by the photoelectric stability *per se*.

A recording or controlling gage must make use of the null point (zero galvanometer deflection) determination to operate a relay of some sort. In general, an automatic gage should be much faster than a visual manually-operated gage, but such a device would probably never be expected to read with a greater precision than to the nearest 0.000

...ief requirements of such a device are, of course, rug...ss and cheapness of construction.

...fulfilling this latter requirement, the designer will ...ally seek to use as component parts of his apparatus ...ials and equipment which are now on the market.

...a generalized experiment, the authors have attempted ...determine the performance characteristics of an auto...ic gage assembled from various sources of commercial ...ipment.

...As a sensitive high-speed relay to be triggered-off by the ...anometer beam, the G.E. Model CR7505G5 was chosen. ...the catalog the operating cycle of this device is given as ...0 second (on the 60-cycle power supply) with positive ...eration on 1 foot-candle. The tube equipment consists of ...PJ-23 photocell, PJ-7 pliotron, and FG-81 thyratron. Con...l current available from the thyratron is 0.5 amp.

The amount of illumination necessary to operate this relay ...easily obtained at a distance of one meter from a 5-mm. galvanometer mirror if the edge of the monoplane filament of a 250-watt lamp is imaged on a slit-covering the photocell housing.

The sensitivity of this relay varies somewhat with the line voltage. At a given sensitivity setting, the lower the line voltage, the farther the edge of the galvanometer image must be moved over the photocell slit to energize the relay.

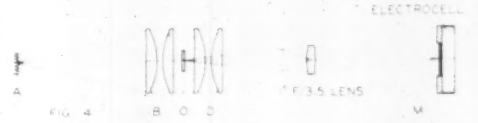


FIG. 4

The first step in ascertaining the requisite sensitivity of the galvanometer therefore consists in determining the shift in the apparent zero of the galvanometer beam required for positive relay operation at the expected limits of variation in the line voltage. With the amount of illumination available from the galvanometer beam, there was a difference of 0.2 mm. in the point of relay operation for a line voltage variation of 5 volts. Obviously, the galvanometer sensitivity must be sufficient so that the deflection commensurate with the smallest dimensional difference to be read shall be considerably greater than 0.2 mm.

The photoelectric current differential resulting from a dimensional variation in the object depends upon the efficiency of the optical system of the gage as well as upon the sensitivity of the cell, and, in order to be specific regarding the operating characteristics of a gage, it is necessary to describe the optical system. A typical optical arrangement for gaging is shown in Fig. 4. In this setup, *A* is a 500-watt monoplane filament lamp, *B* is a condenser placed at its focal distance of 80 mm. from the source, and *D* is a condenser of 30 mm. focal length which converges the parallel rays to a focus in the 25-mm. objective. The filament image practically fills this objective which has an *f* number rating of 3.5. The objective is focused so that an image of object *O* is projected on an "Advanced Type Electrocell." A mask, *M*, is placed over the photocell. This mask has a clear aperture 1" high and 0.1" wider than the image of the object. Thus, an area of 0.1 square inch of photocell surface is illuminated by the optical system. The article to be measured (and of course the variation in its dimension) is magnified 10 times by this system. A variation of 0.0001" in the measured dimension will thus cause a variation in effective aperture width of 0.001". The result is a variation in the cell output of the order of 1%. Since there is good evidence that the stability of the balanced cell circuit is within 0.1%, the amount of variation produced in this instance would seem to afford an ample factor of safety.

Now, with this optical arrangement, a current of about 30 microamps. is produced by the Electrocell, through an external resistance of 400 ohms. When the monitoring photocell illumination is adjusted to the point at which its output exactly balances that of the measuring cell, a change of 1% in the illumination of either of the cells produces a current of 0.2 microamp. The resistance of the cell circuit at the balanced condition is about 400 ohms.

A galvanometer of the minimum requisite sensitivity should undoubtedly be employed in the gage because ruggedness, stability of zero, and speed of response vary inversely with sensitivity. The instrument should be near critical damping for the external resistance supplied by the cell circuit and the coil resistance should be of the same order.

A narrow-coil galvanometer furnished by Leeds & Northrup comes close to fulfilling the requirements of this particular setup. Its characteristics are as follows:

Sensitivity	0.15	microamp. mm.
Period	0.2	second
CDRX	200	ohms
Coil Resistance	203	ohms
Mirror	5.0	mm. diameter

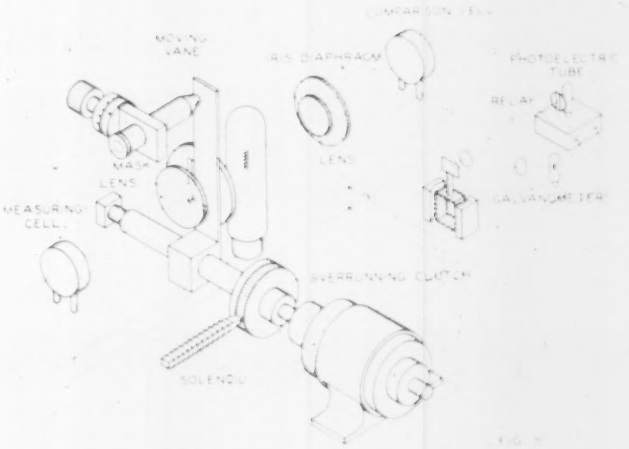


FIG. 5

With this galvanometer-cell combination, the shift of effective zero of the relay with the expected variation in the line voltage of 5 volts amounts to less than 0.2% or, in terms of the dimensional measurement, an error of the order of 0.00002".

The questions of the accuracy and the speed attained in the actual performance of a gage assembled from the commercial parts which have been discussed have been studied with the aid of the apparatus illustrated in Fig. 5. This device consists essentially of a lamp from which two light beams are directed onto two Electrocells. These cells are connected in opposed parallel circuit to the L&N galvanometer. The beam to the right is provided with a manually adjustable iris diaphragm and the second beam contains a rectangular slit aperture which can be closed by an opaque vane sliding transversely to the axis of the beam. This vane is carried by a nut which may be driven back and forth on a spindle as the latter is made to rotate. A variable-speed motor drive moves this spindle through an over-running clutch. This clutch may be instantly disengaged whenever the circuit is made through a solenoid whose plunger brakes the rotation.

The beam from the cell-controlled galvanometer when at the zero position falls on a slit over the G.E. photoelectric relay. The secondary circuit of the relay upon closing energizes the solenoid which disengages the clutch.

The experiment which may be performed with this device is as follows: With a known size of slit opening in the beam which supplies the flux to the measuring cell, the lamp intensity is adjusted to produce a measuring cell current of 30 microamps., which is the level obtainable in the typical optical system of Fig. 4. The manually-controlled aperture in the comparison cell beam is adjusted to balance the galvanometer at its zero position. The screw is then rotated so

as to back off the vane, thereby unbalancing the cell circuit. Balance may be restored either by slow manual rotation of the spindle or by engaging the motor drive to close the aperture and decrease the intensity at a faster rate.

At the point of balance, the relay operates to disengage the clutch and a measurement of the stop position is made with a traveling microscope.

A number of readings were taken of the stop position for each of five different rates of vane movement. The first rate was extremely slow—to determine the best possible accuracy of the system. For the second rate, the aperture area at the moment of balance was changing 4% per second, which, referring to the typical gaging optical system, corresponds to 0.0004" per second. The rate was increased in steps up to a value of 40% per second, at which point it was decided that the error was too large for a gage meant to read to 0.0001".

Probable errors for each rate were calculated by the method of least squares and the results are given in Table I.

TABLE I

Probable Error in Stopping Position

Rate % per sec.	Probable Error %
1	0.074
4	0.08
10	0.10
20	0.11
40	0.39

One interested in the practical performance of an automatic gage might be more enlightened by what is sometimes spoken of in probabilities as the "huge error" (approximately five times the probable value). This is the error than which only one out of a thousand is greater. For the practical gage using the typical optical system (Fig. 4) the "huge errors" and the gaging rate, both in inches, are given in Table II, which is computed from Table I.

TABLE II

"Huge Error" vs. Gaging Rate for an Instrument Employing the Typical Optical System

Rate (Inches per second)	Huge Error (Inches)
0.0001	0.000036
0.0004	0.000039
0.0010	0.000049
0.0020	0.000054
0.0040	0.000019

From the foregoing data, it is possible to determine whether a photoelectric recording or controlling gage is suitable for a specific problem. For instance, by assembling the commercially available components used in this experiment, it would appear safe to say that an instrument could be made which could in one second measure objects to the nearest 0.0001", provided that the maximum variation from article to article does not exceed 0.001".

A few additional miscellaneous remarks regarding photoelectric gage designs are apropos.

In designing an optical system, it is desirable to locate the photocells so that they will operate at about the same temperature. This is one requisite of a system of high stability. In general, it is best to use both cells either in the horizontal or the vertical position, and in the same housing to ensure equal temperature. An additional recommendation is that the pair of cells be tested to ascertain, first, that they respond equally to lamp voltage changes and, second, that they fatigue at approximately the same rate so that the balance point will not shift with time of exposure.

Reflections at the edges of gaged samples must be avoided because a difference in reflectance of two different samples may introduce a serious error. This difficulty will seldom arise if the article to be measured is thin, but precautions must be taken if the thickness is large in comparison to the measured dimension. This is especially true if the surface is highly polished, *e.g.*, the contour faces of gear teeth.

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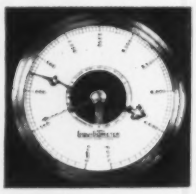

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Rebound Methods of Measuring Hardness

By S. R. WILLIAMS
Professor of Physics, Amherst College

Concluded from December Issue

THE DUROMETER

Sauveur[7] has devised an instrument employing the rebound principle. It has been called the Durometer. It is simple in operation and, when certain precautions are observed gives good results. A steel ball, usually a 10 mm. ball as manufactured for the Brinell hardness tester, is allowed to fall through a definite height and strike the polished surface of the specimen to be tested.

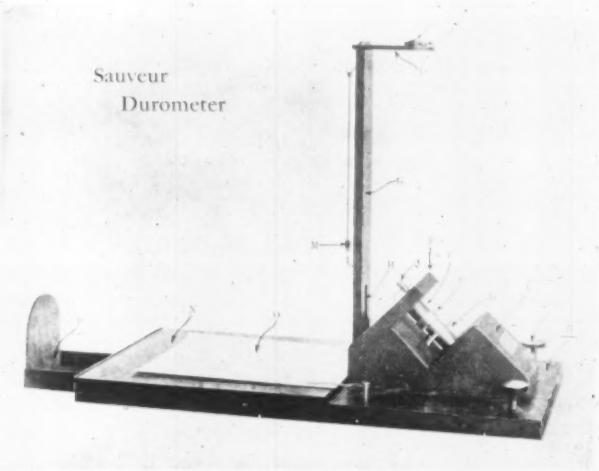

Fig. 186. Sauveur's Durometer, an instrument which employs the rebound principle.

Fig. 187. Diagram of Sauveur's Durometer.

This test surface is inclined at an angle of 45° with the horizontal. See Figs. 186 and 187. When the steel ball strikes the surface it rebounds along the parabolic path indicated. The rebounding impulse given to the ball when it strikes the test piece, will be increased by the hardness of the sample. This was indicated in the theory on the preceding pages. The distance, *d*, Fig. 187, which the ball travels horizontally from the test specimen, will be a measure, therefore, of the hardness of the sample.

[7]A. Sauveur: The Durometer, an Instrument for Testing Hardness. *Transactions American Society for Steel Treating*, Vol. 9, 1926, pages 926-934.

This distance is measured by placing a glass plate G horizontally on the base, *B*. On top of this is superimposed a sheet of white paper on which is laid in turn a piece of carbon paper with the ink side next to the white paper. When the steel ball strikes the carbon paper an imprint is made on the sheet of white paper as shown in Fig. 188 and thus a permanent record is preserved. Fig. 188 shows a record which Sauveur made of three different kinds of steel under different heat treatments. *R* as received, *A* as annealed, *N* as normalized, *Q* as quenched and *QD* as quenched and drawn. Samples 1 inch in diameter and 1 inch thick were used. The readings as taken from the sheet in Fig. 188 were as follows:

Carbon	*R*	*A*	*N*	*Q*	*QD*
0.10	51-53	44-44	47-47	62-62	54-54
0.30	56-56	50-50-52	52-52-53	84-86	76-76
0.80	67-68	68-69	71-72	86-83-83	75-76

The ball was allowed to fall by laying it in an iris diaphragm and slowly opening the same. The ball fell from a maximum height permitted by the apparatus in the readings given above.

The conditions necessary to obtain satisfactory readings are: (1) careful leveling of the apparatus; (2) constant mass and hardness of the steel ball used; (3) constant height of fall; (4) gradual opening of the diaphragm in releasing the ball; (5) use of specimens, preferably not less than one inch thick and one inch wide; (6) smooth surface for testing; (7) preventing the ball from striking near the edge of the specimen; (8) holding the specimen in place under constant pressure and (9) preventing the ball from striking twice in the same spot. This is an instrument easy to construct and not expensive.

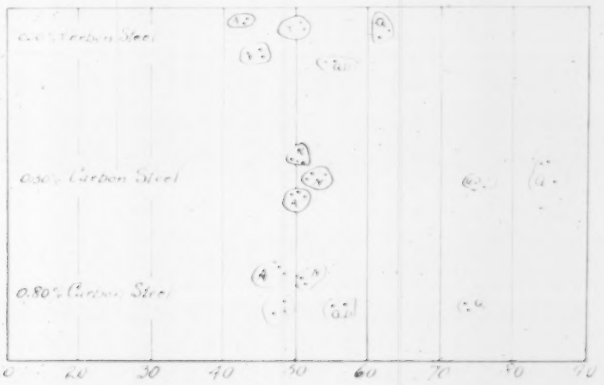

Fig. 188. Graph showing the Durometer Hardness of three different carbon steels.

TESTING STEEL BALLS BY REBOUND PRINCIPLE

Some years ago a firm engaged in making steel balls put the wrong steel through the works. Some of the balls from this steel seemed to be satisfactory, but some were entirely too soft. It meant quite a saving if the soft balls